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CALIFORNIA
FOREST and RANGE
EXPERIMENT STATION
GEORGE M. JEMISON, DIRECTOR

FOREST SERVICE - U. S. DEPARTMENT OF AGRICULTURE

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Please insert the following on page 8, Staff Publications, California Forest and Range Experiment Station, 1950-1951, under Stone, E. C., third item, instead of the one listed:

1950 * Water absorption from the atmosphere by plants growing in dry soil. By E. C. Stone, F. W. Went, and C. L. Young. Science 111(2890): 546-548. May 19. 1950.

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INTRODUCTION

For more than a decade now, the demands of increasing population and industry have brought greater pressure each year on the renewable resources of California. Again in 1953, many events emphasized the need for wise resource management and for the knowledge upon which to build sound management programs. Population continued upward at record rates, creating new local demand for timber, forage, and water. Timber cutting continued almost at the peak level of 5 billion board feet that was established in 1951. A decline in cattle prices, intensified by widespread drought in the Southwest, placed a premium on efficiency in range management. Prolonged dry weather made a tinder box of southern California, where fires caused the greatest destruction of watershed cover since 1919, dramatically illustrated the need for advances in fire-control techniques, and set the stage for severe flood damages. The State made plans for large-scale diversion and transport of water in the streams that flow from the wildlands, bringing closer the day when management of these lands must place more emphasis on their water yield.

Besides the continued high output of forest products, some changes in wood use were evident in 1953. Lumber production probably was a little under the record set in 1951, but plywood and veneer output increased as some new plants came into production. Of equal interest to the industry were two significant developments in the pattern of wood utilization. One, the first major change in packaging agricultural products in many years, was the introduction of fibreboard containers for lettuce and lemons. This has stirred interest in use of paper-covered wood veneers for lightweight boxes and in finding ways to strengthen the competitive position of sawed wood boxes. The second significant development is the increased use of slabs and edgings to produce wood chips for pulping or fiber products. The raw material needs of a large pulp industry could be met by the large volumes of slabs and edgings developed at sawmills in the state, but this use of sawmill residues appears to be limited in California by a relatively small market for chips. To help expand the market, research will need to develop techniques by which fiber products can be made with little or no water. These problems and others arising from high production, have kept our two-man Forest Utilization Service busy supplying industry with information on wood properties and manufacturing methods.

High production also emphasized the need for information on the nature and extent of forest resources, and state-wide figures are now being assembled by our Forest Survey staff. Preliminary figures indicate that the timber supply in California is considerably larger than was previously estimated, particularly the volume of true firs and Douglas-fir. However, some species are being cut heavily, and we need to stress the gathering of information on management of existing timber, regeneration of cut-over areas, and improvement of forest trees. Forest managers need to know how to get the most timber over a long period of time from existing stocks. For example, how much additional wood can be recovered by sanitation-salvage cutting? Can existing old-growth stands be kept in a reasonably thrifty, growing condition? What is the effect of markets on overcutting of some species and grades and undercutting of others? The Station's long-term major study at Blacks Mountain Experimental Forest is seeking information on conversion from wild to managed forest for the eastside pine type, and we have placed emphasis upon summarization of results from this project to date. During 1953 the difficulties of forest regeneration in California were recognized by the State Board of Forestry, which appointed a special committee to study tree planting and artificial and natural seeding problems. The Station is represented on that committee, and a large share of our forest management research during the past year was directed toward the problem of bettering the establishment of conifer seedlings. Also, our forest genetics staff increased its efforts to select and collect outstanding individuals among the western pines. This collection will permit us to conduct breeding tests of trees with contrasting characters and to determine how these characters are inherited. Eventually we should be able to produce superior trees "tailor-made" for regeneration of Pacific Coast forests.

In adjusting to the changing price situation during the past year, the livestock industry moved toward more intensive management of range lands. Cattle numbers already are high, so the rancher is looking mainly for bigger crops of range forage and more efficient utilization of the forage. The importance of deer management on lands grazed by cattle and sheep also is becoming more widely recognized as a means of improving use of the range resource. Help in making the adjustment is available from several phases of the Station's range research program. This work in 1953 demonstrated ways to improve forage production by range fertilization, by weed control and reseeding, and by grazing management. And a two-year-old cooperative study on game ranges has turned up some of the clues to successful planting of browse species -- and at the same time revealed some large gaps in the information needed for large-scale browse reseeding. Reorganization within the Department of Agriculture, which took effect as the year ended, transferred certain range studies from the Forest Service to the Agricultural Research

Service. Two of this Station's range technicians were transferred to Agricultural Research Service; their studies are expected to continue under that agency in close cooperation with this Station.

California is notorious for severe forest fire conditions, but three things especially stand out about the 1953 fire season. For one, southern California experienced unusually severe burning conditions while the rest of the State had a relatively easy year. That a wide geographical variation exists in severity of fire weather was also shown by a study of fire danger records, completed this year. A better understanding of this variation could permit more efficient use of available fire-fighting resources. The second lesson was that a few bad fires caused more than 90 percent of the 1953 fire losses. This is not a new lesson, but one worth emphasizing. Evidently we need to go far beyond today's knowledge of fire behavior and control techniques if we are to check such explosive fires. Attention has been centered on these problems by our small fire research staff, and the work of our special cooperative project on forestry problems associated with national defense will contribute important basic information. As the defense situation permits, results of this project work will be released. Third, the flood and erosion hazards after fires in southern California mountains are becoming well known. Newspapers gave prominence to fire damage estimates based on the Station's studies of flood peaks and erosion after fire, residents were warned of increased flood dangers below the burned areas, and flood-control agencies made plans to reduce the damages expected when winter rains washed mud and rocks from the raw slopes.

Water supply for industrial, agricultural, and domestic use continued to be of concern to the entire State. Plans were completed for the State's most ambitious water transport project. This would dam the Feather River, provide 2.7 million acre feet of water a year, and carry the water by stream channel, canal, and tunnel as far south as San Diego, a distance of about 650 miles. As this and other projects are built, more and more of the available reservoir sites in the State will be used for water storage and flood control. Other opportunities for controlling the flow of water and the sediment load of streams will lie in management of forest and range lands. These are the principal source areas of the State's water supply, its floods, and the sediment in its streams, and the Station's research on water problems is directed toward management of these lands for their water yield. Most of our work in 1953, as in past years, was carried out in southern California, in cooperation with the California Division of Forestry. This year the Los Angeles County Flood Control District also helped support the research program. Two state-wide erosion studies were brought close to completion, and we were able to make a preliminary analysis of

possibilities for improving the yield of water from the Sierra Nevada snow pack.

On the following pages we are reporting in greater detail the findings highlighted here. Certain other results of our research which we believe are significant to managers of California's wild lands are also reported. But we have not attempted to cover the scope of the Station's program. Some long-term studies are not yet ready for summarization, others are only getting started. These will be featured in the years ahead. The coming years will also bring to the Station new responsibilities for research on forest insects and diseases. Reorganization of the Department of Agriculture assigned responsibility for this work to the Forest Service. By year's end this Station had completed arrangements for two new divisions to carry out the research in California. Our Division of Forest Insect Research will be staffed by technicians of the Berkeley Forest Insect Laboratory; our Division of Forest Disease Research, by technicians of the Division of Forest Pathology in San Francisco. Workers in both units, formerly assigned to the Agricultural Research Administration, have carried out their studies in close cooperation with the Station since it was established, and as members of the Station they will continue their major lines of work in a coordinated program of forest research.

FOREST MANAGEMENT RESEARCH

More than 14 million viable sugar pine and ponderosa pine seeds were produced on 46.8 acres of the Stanislaus Experimental Forest during two periods totalling 16 years, according to records we compiled in 1953. This vast amount of seed produced slightly more than 3,000 established seedlings on the same area. Obviously 3,000 pine seedlings on 46.8 acres is not satisfactory stocking. What happened to the other 13,997,000 seeds? If 50 percent of the seed had germinated, and 25 percent of the resulting seedlings had survived, we would now have 1,750,000 trees--an excessive number--on the 46.8 acres. But somehow the crop was reduced to a mere 0.02 percent of the potential. This example indicates, in a simplified way, one of the most critical forest management problems in the California region.

STUDIES SHOW CAUSES OF MISSING SEEDLINGS

The Station has conducted many experiments in past years in attempts to learn how to increase the establishment of seedlings. Much has been learned about methods for encouraging conifer seedling establishment, but we must admit that some serious drawbacks still have not been

overcome. During 1953, a substantial portion of the Division of Forest Management's time was directed toward the problem of bettering seedling establishment. Many factors hinder the establishment of seedlings. Among the more important are seed-eating animals, herbivorous insects, and physical conditions of site such as drought, smothering by fallen leaves, and competition from other plants. Some of the past year's findings show what happens to the missing seedlings.

Seed-destroying animals, and methods for lessening damage were studied independently by the Experiment Station, and in cooperation with other organizations. Evidence gathered in 1953 showed that seed-eating mammals have sometimes been assigned an unduly high share of the blame for the missing seedlings. Although this is not a new discovery, it may surprise a good many foresters. For example, the better stocking of screened seedspots, when compared to unscreened seedspots is often regarded as evidence of losses caused by seed eaters. However, the screens placed over seedspots also provide beneficial shade, they retard soil movements which may either bury the seedlings or expose the roots, they prevent smothering by leaves, and lessen the danger of trampling by hoofed animals.

A ponderosa pine seed spotting experiment conducted on the Blacks Mountain Experimental Forest shows rather clearly that cone-shaped screens provide substantially more protection than mere exclusion of seed eaters. Germination was almost as good without screens as with screens where the seeds had been poisoned with tetramine or the area had been poison-baited (table 1). However, unscreened seedspots which had been protected by poison--both "1080" and tetramine--experienced substantial post-germination losses. Seven different causal agents were recognized, of which two--cutworms and drought--were more severe and seemed to damage the unscreened spots more seriously. However, seed-eating mammals remain as the largest single damaging agent in these studies and similar studies in the Douglas-fir type in the North Coast Range and in the Sierra Nevada.

Cooperators in these studies included the Yosemite Mountain Ranch, Ltd., the U. S. Fish and Wildlife Service, and the Department of Zoology, University of California. Dr. E. W. Jameson, Jr., and Lloyd Tevis, Jr., of the University published four papers concerning various aspects of the life histories and food habits of several important seed-eating vertebrate animals during 1953. In a short note in the Journal of Forestry, Mr. Tevis reported that contrary to an earlier account from another source, he was unable to find that paper covers over seed-spots protected the seed from rodent depredations.

Table 1.--Germination and stocking in protected and unprotected seedspots

Item	Germination, one or more seedlings per spot	Stocking at end of growing season
	. . Percent . .	. . Percent . .
Tetramine-treated seed		
Screened spots	99.5	67.0
Unscreened spots	91.5	23.5
Untreated seed		
Screened	95.5	53.0
Unscreened	59.5	10.5
"1080" poison-baited area		
Screened	100.0	68.0
Unscreened	90.0	11.0
Unpoisoned area		
Screened	93.8	53.0
Unscreened	46.2	3.0

Physical site factors that affect tree survival were investigated in connection with the planting of seed and nursery-propagated trees on the Trinity National Forest and Six Rivers National Forest. Ponderosa pine proved superior to Douglas-fir in initial establishment on the warmer and drier sites. For planted trees, survival after two years was as follows:

Aspect of planting site	Relative elevation on slope	Percent survival	
		Douglas-fir	Ponderosa pine
South	Low	17	34
North	Low	62	41
North	Medium	29	38
North	High	36	38

On screened seedspots, there was little difference in germination between Douglas-fir and ponderosa pine seed. After one growing season, however, differences were apparent between the species. Ninety-five percent of the ponderosa pine seed spots had seedlings on north-facing slopes, 90 percent on south-facing slopes. Comparative figures for Douglas-fir were 80 and 30 percent.

Competing vegetation is generally harmful to small conifers, but sometimes the shade created by shrubs and trees aids in the initial establishment of the trees. At Blacks Mountain Experimental Forest, ponderosa pine natural reproduction germinated better and had higher survival after four years on bare soil than in vegetation composed chiefly of squaw carpet (a creeping shrub) and grass. Planted ponderosa pine and Jeffrey pine in the same locality also survived best on bare soil. Neither squaw carpet nor grass create much shade. But on the Trinity and Six Rivers national forests shade from taller shrubs and trees aided survival of planted Douglas-fir during the first growing season, as shown by the percent survival:

Shade intensity	Trinity National Forest	Six Rivers National Forest
Heavy	85	86
Medium	84	72
Light	79	62
None	62	40

It remains to be seen whether the shade will hinder future growth.

PLANTING STOCK STORAGE TESTS ARE CONTINUED

During 1953, the results of several nursery stock storage tests were summarized and published for the information of nurserymen. Briefly, the principal conclusions were: (1) Over-winter storage of ponderosa pine and Jeffrey pine nursery stock is feasible; (2) the resulting reduction in survival and growth after field planting is less objectionable than the losses which may result when nursery lifting dates and the best time for field planting do not coincide; (3) 36° F. is apparently a near-optimum temperature for storage.

During 1952-1953, large scale over-winter storage experiments were conducted at Shasta Nursery and follow-up field trials were made to test several kinds of packing, wrapping, and container materials, the use of a transpiration retardant, and two methods of stacking the stored stock. Although some differences were found between the various treatments of the stored stock, the differences could not be regarded as of practical significance because of exceedingly low field survivals. Two months after planting, survival was reasonably good but at the end of the growing season, average survival was only 7 percent, apparently owing to a combination of a droughty planting site and a dry summer rather than harmful effects of storage. Therefore, the more promising of the storage experiments are being repeated next year.

GRADED PLANTING STOCK PRODUCES LARGER TREES

One long-term study summarized during the year showed how the quality of nursery stock can be improved by grading. When ponderosa pine and Jeffrey pine nursery stock were sorted into three size classes, appreciable differences in tree height could still be detected 9 years after field planting (table 2). Sorting the seed from which the stock was produced into size classes, however, did not result in similar differences. As one measure of the effect of grading, we determined how many of the trees in each grade were among the tallest 25 percent of the field plantings after 9 years. We found that 82 percent of these "best trees" had originated from stock that was graded large or medium as 2-year-old transplants; about 80 percent from stock graded large or medium as 1-year-old seedlings. The tallest 25 percent of the trees were about equally divided among the three seed size classes. These findings have been published in the Journal of Forestry.

Table 2.--Average tree height 9 years after planting, by size of seed or stock

Size class	Jeffrey pine	Ponderosa pine
	(inches)	(inches)
Seed:		
large	48.7	48.9
medium	51.8	48.2
small	50.3	46.9
1-0 Seedlings:		
large	54.1	50.5
medium	50.9	48.3
small	45.8	45.3
1-1 Transplants		
large	56.0	51.6
medium	50.6	48.7
small	44.3	43.8

RELATIONSHIP ESTABLISHED BETWEEN TREE SIZE AND SEED CROPS

Size for size, sugar pine trees are relatively less reliable cone producers than white fir and ponderosa pine until they reach about 28 to 30 inches in diameter. In practical terms this new estimate means that comparatively large diameter sugar pine trees must be left in or around cutover tracts to insure a seed source for natural

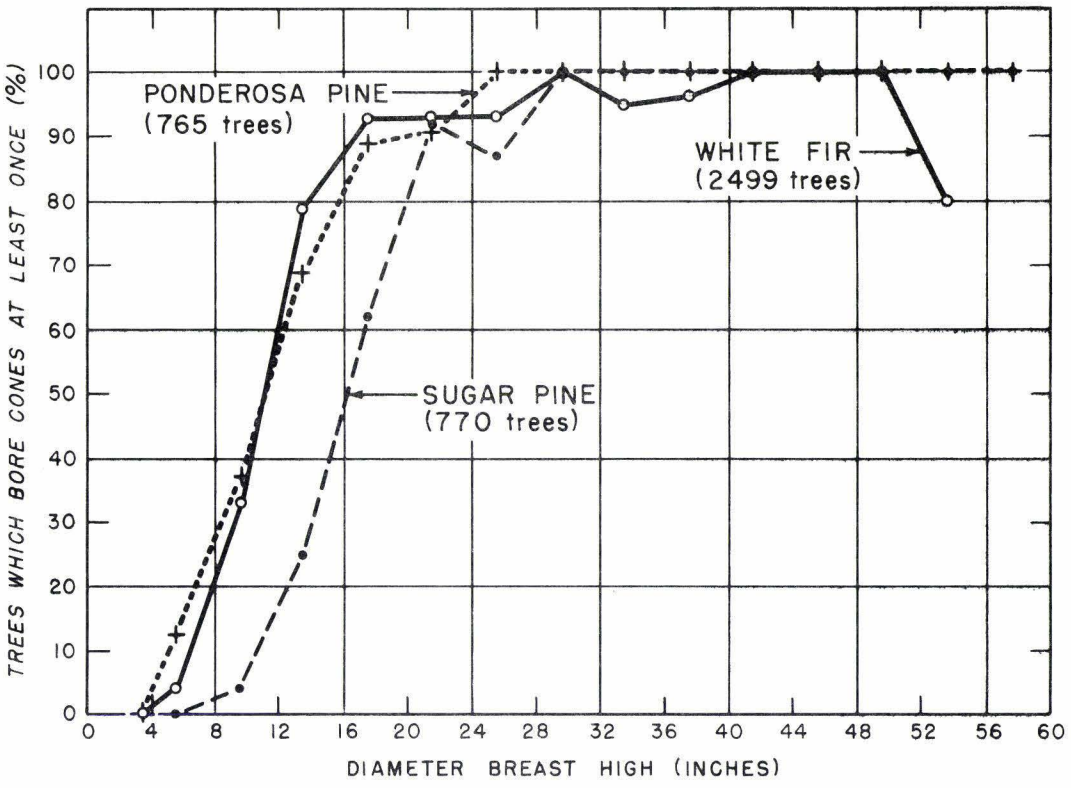

Figure 1.--Proportion of residual trees in cutover stands bearing cones, by diameter classes. (Observation period 8 to 15 years.)

reseeding. We have recorded in figure 1 the percentage of trees in different diameter classes which bore cones one or more times during a long-term study by the Station. At first glance, it may appear that the three species do not differ greatly. Closer inspection of figure 1, however, will show for example that in the 14-inch diameter class, only 25 percent of the sugar pine bore cones, in contrast to about 70 percent of the ponderosa pine and 80 percent of the white fir.

Not all white fir larger than 30 inches diameter bore cones during the observation period probably because the upper crowns of many white fir are seriously injured or killed by mistletoe and accompanying secondary attacks by a bark beetle. Since white fir bears its cones in the uppermost portions of the crowns, injury to that portion would tend to prevent production of cones.

The new estimates provide considerably more precise information than was previously available concerning the seeding habits of California's finest pine tree--sugar pine--and some

of its common associates. The information was obtained from long-time records which have been collected in the Sierra Nevada mixed-conifer type. Other important data which are now being summarized include the frequency of seed crops, the number of cones per tree by size-classes, and the number of seeds per cone. For instance, the average number of cones produced by 14-inch trees was: For sugar pine, 8 per tree; for ponderosa pine, 36 per tree; and for white fir, 50. These numbers and other factors must be weighed in evaluating the effectiveness of a seed crop. The ultimate purpose of the project is to provide better basic information upon which to plan harvesting and regeneration methods.

STUDIES MEASURE VOLUME GROWTH IN CUTOVER PINE STANDS

Ten-year records from cutover ponderosa-Jeffrey pine stands show how much the method of cutting and the size and age of the timber influence post-logging growth. The studies being conducted at Blacks Mountain Experimental Forest are located in stands in which the merchantable size trees are mostly overmature. As has been previously reported, such stands typically suffer repeated losses from bark beetle attacks, and it is possible to convert the net growth of the stands from a practically static condition to a substantial plus volume by harvesting the high risk trees. The actual improvement in growth on measured plots amounted to 115 board feet per acre (table 3).

Table 3.--Growth and losses by method of cutting[1/]

Item	Uncut	Risk cut	Moderate cut	Heavy cut	Clear cut
	(board feet per acre)				
Volume after cutting	18,465	15,808	8,326	5,092	598
Growth per acre per year[2/]	93	127	88	85	69
Losses per acre per year	101	20	15	7	1
Net growth per acre per year	-8	107	73	78	68

1/ Basis - four 20-acre plots for each method
2/ Includes ingrowth.

The 10-year growth was further analyzed by age-classes of trees. The results indicate that where younger trees predominate in the residual stands, net growth is materially higher. Especially in young age-classes where it was possible to leave a heavy reserve, growth was strikingly higher, as may be seen in the following tabulation:

Age class	Reserve volume per acre	Net growth per acre per year	Basis (1/10 acre units)
	(board feet)	(board feet)	(number)
300+	21,661	104	407
75 - 150	5,757	184	300
75 - 150	21,512	393	17

That young trees grow faster than old trees is well known. The importance of the growth rates shown in the tabulation is that they give an idea of how much greater the growth of young trees actually is in the eastside pine type. Growth in the overmature cutover units was also compared with the size of the trees in each unit. Stands composed of smaller trees grew better than those composed of larger trees, as shown by net annual growth per acre:

Approximate diameter range, inches	Reserve volume per acre	Growth per acre	
	(bd.ft.)	(bd. ft.)	(percent)
23 - 29	20,608	103	51
29 - 33	25,341	92	37
33 +	32,569	55	17

In order to establish sustained yield after the initial risk cut, harvesting of the remaining overmature timber must be spread over a long period. Therefore, according to these growth data, overmature units composed of smaller trees should be held the longest.

The results described here were brought out while making a major analysis of the pine management project at Blacks Mountain Experimental Forest. The analysis is still continuing. We plan to complete a preliminary draft during 1954.

These studies have been conducted in cooperation with the Forest Insect Laboratory. Under the new Departmental reorganization plan, which transferred the forest insect research to the Forest Service, even closer coordination is anticipated for studies concerned with management of timber subject to serious insect losses.

FOREST GENETICS RESEARCH

Perhaps the most spectacular results of the Station's research in forest genetics during 1953 were the four new pine hybrids certified in the nursery at the Institute of Forest Genetics. These 4 hybrids brought to 35 the number of new pine combinations containing one or more California species. Several of these continue to show exceptional promise in nursery and field trials. Nevertheless, the most important development during 1953 was not the certification of new hybrids, nor the continued superiority of some hybrids. Much more important in the long run was the increased effort we were able to make in studying the variability among western pines. By selecting outstanding individuals among these important timber pines, we are building a collection of trees with widely contrasting characters, such as tree form or disease resistance. These trees will be used in breeding tests to study the way different characters are inherited. These tests and other basic studies are expected to uncover facts that eventually will permit tree breeders to use parent trees of known superiority in producing superior trees for the forests of the western states.

NEW PINE HYBRIDS INCLUDE CROSSES OF THREE SPECIES

Of the four new hybrids verified in the 1953 nursery, three are three-species crosses. They include one cross using white pines of the United States and Asia and two crosses using western pines of the ponderosa pine complex. The fourth new hybrid is a first generation cross of two western pines. The new combinations are:

Seed parent	Pollen parent
Western x eastern white pine hybrid	Himalayan white pine
Jeffrey x Jeffrey-Coulter hybrid	Ponderosa pine
Ponderosa x Apache hybrid	Montezuma pine
Apache pine	Montezuma pine

The new white pine cross is of particular interest because the Himalayan white pine is a rust-resistant Asiatic species. An earlier, two-species cross of eastern white pine and Himalayan pine gave a hybrid that has resisted blister rust in a test plot for 8 years.

The possible benefits from crossing a hybrid to a third species may be illustrated by the new Jeffrey-Coulter-ponderosa pine hybrid. At one-year its height was 125 percent of that of ponderosa pine and 175 percent that of Jeffrey pine. Moreover, it probably has inherited resistance to the western pine beetle from Jeffrey pine, and it may contain enough Coulter pine heredity to make it resistant to the pine reproduction weevil. It is a fair assumption that Jeffrey pine has contributed enough frost resistance to adapt the new cross to most of the range of ponderosa pine in California. As all the parental species exhibit good form on a good ponderosa pine site near the Institute of Forest Genetics, good stem quality should also be one of the hybrid's characteristics. The contribution of ponderosa pine, which we have not been able to cross directly to Coulter pine, probably consists chiefly of vigor and general adaptability to ponderosa sites. Finally, there is evidence that, once the hybrid seed-parent trees attain vigorous flowering, the tri-species hybrid can be produced in considerable abundance.

The other two new hybrids are of special interest because each includes Montezuma pine, which evidently is outstanding in height growth, and Apache pine, which is noteworthy for exceptional diameter and root growth. If these hybrids perform as have other hybrids containing these species, a remarkable combination of diameter and height growth can manifest itself. All previous crosses with Apache pine have exhibited exceptional diameter growth at the outset. These new hybrids do also. Height growth of hybrids containing Montezuma or Apache pines has started slowly but accelerated after the first or second year. At one year, for example, ponderosa pine surpassed the ponderosa x Montezuma hybrid by 1.27 inch. At two years, however, the hybrid surpassed all ponderosa pine progenies in the same nursery by at least 5.28 inches. The new tri-species hybrid containing Montezuma pine has 4 to 5 needles per bundle. Thus, in this cross, the genes for superior diameter growth and high needle-number, contributed by Apache pine and Montezumae pine respectively, are able to express themselves even though only one of the three species represented in the cross contributes to each of those characters.

During 1953, 85 new crossings were attempted as part of the artificial pollination program in the pines which has long made up the bulk of our forest genetics work. These pollinations are planned as a complete reconnaissance of the pines of the world, to show hybridizing relationships and to provide guides

to economic potentialities of the hybrids obtained. Because most pines require two growing seasons to produce mature seed, the outcome of the pollinations made in 1953 will not be known for some time. The number of different crosses attempted, by kind and purpose, was:

Kind of cross	Purpose	Number different crossings
Interspecific F_1	Determine crossability and characters	20
Interspecific backcrosses	Determine characters	7
Three-species	Determine crossability and characters	15
Four-species	Determine crossability and characters	2
Intraspecies	Effect of freezing pollen, and heredity of crown types	41
	Total	85

CALIFORNIA PINES NOW REPRESENTED IN 35 HYBRIDS

As a result of its hybridization program in the pines, the Station has produced and partially tested about 65 hybrid combinations. Because of the richness of pine breeding materials in California, the native pines are represented in more than half of these combinations. Of the 38 species and varieties of pine listed in the new "Check List of Trees of the United States," 19 occur in California. They are almost equally divided between the soft and hard pines, including such highly valuable species as sugar pine and ponderosa pine. Both groups of pines occupy sites varying greatly in soil and climatic conditions, from foothills to sub-alpine peaks, and from the humid coast to the edges of deserts. Nine of these species also grow in Mexico, and seven of them range northward into Canada. The range of one, lodgepole pine, spans 35 degrees of latitude, from Baja California to the Yukon. Thus the native pines of the California region alone constitute a great reservoir of highly variable breeding materials--only in Mexico do pines occur in such diversified abundance within an equivalent area. Also, we can draw upon many pines not native to California--about 12 soft pines and 50 or more hard pines, many of which are growing in the Eddy Arboretum at the Institute of Forest Genetics.

It is from this supply of raw materials that the Station has produced about 65 hybrid combinations by controlled pollinations. One or more California species are represented in 35 of these crosses; 21 are first-generation hybrids, 10 are progenies of hybrids arising from inter-crossing different trees of the same hybrid and from backcrossings, and 4 are three-species crosses. All these hybrids are of considerable academic importance because of the light they shed on the heredity of the pine family. Many of them have performed impressively in nursery and field tests. Most have outgrown one of the parent trees, and a few have outgrown both parents. Some have exhibited strong resistance to insects or disease. Their full practical importance, however, cannot be judged by those criteria alone because it is in their breeding potentials that the greatest value of many of them may lie. These potentials were illustrated by the new Jeffrey-Coulter-ponderosa hybrid which we hope eventually can be produced in considerable abundance. If these expectations are realized, a tree of general excellence will have been produced for use in a large area of the Pacific Coast states through synthetic breeding alone. This and other hybrids can eventually be improved through selection, and such improvement is one aim of our studies of variability among the western pines.

SELECTIVE BREEDING TRIALS SEEK IMPROVED WESTERN PINES

Systematically crossing the different species of pines (the hybridization reconnaissance) shows what improvements, in general, may be expected from a particular cross. Also, as has been the case for some crosses made in our reconnaissance, many resulting hybrids show enough superiority to warrant field trial by interplanting with standard strains. No breeder, however, would be satisfied for long with these hybrids, great as their superiority might be, for they have been made mostly without the benefits of aim and selection. The reconnaissance has established a point of departure in breeding for a particular locality and purpose.

The next step is to use parents from the proper localities, and, within those localities, to select parents having the best heredity for the purpose in view. To be most effective, this step requires critical studies of the variation and heredity of pine species. Because ponderosa pine is economically important, wide-ranging, and closely related to numerous other species, a critical study of the variation and heredity of it and its relatives is especially important to western regions. Such a study, started late in 1952, is being conducted with the aid of grants by Mr. Fred Searls, Jr. Space permits only a brief statement of the main features of this study.

Ponderosa pine, its varieties, and the species related to it (Apache pine, Jeffrey pine, Coulter pine, and probably a dozen Mexican species) are treated as a group in this study. Priority is given to the ponderosa pine complex. Study of natural variation entails surveys of the distribution of various pines. These surveys will make note of natural hybrids, trees that appear to have exceptionally desirable growth rate, form, or other characters, and trees with strongly contrasting characters. Such trees, selected by appearance, are called phenotypes. From them scions will be taken for propagation by rooting or grafting at the Institute of Forest Genetics. As they come into flowering, their hereditary behavior will be investigated through breeding tests, and types which are inherently good or inherently poor, called genotypes, will be revealed. Most of the poor genotypes will be discarded, but extreme variants will be retained to be used as breeding tools. Good genotypes will be multiplied vegetatively and used in hybridizing until improved forms have been developed. In some cases, progenies of the good genotypes may be used in reforestation. Meanwhile, data on variation and heredity will continue to be obtained from the hybridization reconnaissance, and additional selections will be made among the variable progenies of hybrids.

During 1953 good and poor phenotypes of several western pines were found and tagged in various mountain ranges in southeastern Arizona; and controlled pollinations were made among trees of three species in the Sierra Nevada having contrasted crown characters.

Also during the year, the first disease inoculations were made for a study of how resistance to rust is inherited in ponderosa pine. Two-year-old trees obtained from controlled pollinations between ponderosa pines selected for apparent resistance to the rust (Cronartium harkensii) were subjected by personnel of the Division of Forest Pathology to extremely heavy inoculation with the rust. Conditions were far more favorable to inoculation than are likely to occur in nature. The young trees included some from an infected seed parent and some from an uninfected, apparently resistant, seed parent. The progenies from the infected seed-parent now have about twice as many galls as the progenies from the uninfected seed-parent. Almost 98 percent of the seedlings are infected, and differences in vigor are small; therefore, the large difference in number of galls suggests variation in resistance which behaves as a recessive character. Three seedlings, all from the uninfected seed-parent, resisted or escaped infection and will be planted out. If results of future inoculations on them are negative, they will be of considerable value as breeding tools. Meanwhile the uninfected parent will be favored in future breeding work because it is fairly vigorous as well as apparently resistant.

As in the preceding three years, the Station cooperated in the international research program for the development of rust-resistant white pines by sending a staff member to collaborate with workers in northern Idaho; by making crosses between non-resistant American white pines and a resistant Asiatic species; and by grafting selected resistant stocks received from cooperators. Among the grafts planted this year for breeding tests were rust-resistant selections of eastern white pine from Wisconsin, supplied by A. J. Riker, University of Wisconsin; western white pine from Idaho and Montana, supplied by R. T. Bingham, U. S. Forest Service; and sugar pine from northern California, supplied by D. R. Miller, U. S. Forest Service. Two-year-old hybrids between western and eastern white pines selected for rust-resistance have outgrown trees obtained from controlled pollinations of western white pine trees similarly selected for rust-resistance. A similar result was observed in northwestern Washington.

NEW FIELD TESTS ESTABLISHED WITH HYBRIDS

Field testing is an essential part of the pine-hybridization reconnaissance and the variation and heredity studies. Such tests are conducted at various places by the Station, often in cooperation with others, or by others with materials supplied by the Station. Most of these tests are small, opportunistic experiments using hybrids made without aiming at the particular locality in which the tests are situated. Others, both small and large, are made in the regions to which one of the parents is native. Both kinds may serve various purposes: (1) They yield information on performance; (2) if the hybrids prove successful, they may eventually become seed-production and breeding stands; and (3) occasionally they are near enough to highways to be good demonstrations.

During the year, five new plantings of interspecific hybrids, one of an intraspecific cross, and one of stocks arising from seed irradiated by Dr. Sax at the Arnold Arboretum were set out at the Institute. Two small tests of hybrids were established in the hills east of Berkeley in cooperation with the East Bay Municipal Utility District, their main purpose being to test drought resistance. Seed or planting stock of hybrids also were sent to several cooperators, who will establish tests in seven states in the United States and in five foreign countries.

BIOCHEMICAL STUDIES OF PINES CONTINUED

Continuation of the biochemical investigation of pine-turpentines was assured by a new Rockefeller Foundation grant of $7,300 for one year to Dr. N. T. Mirov through the University of California. The original grant of $10,000 for two years terminated in 1953.

This comprehensive study seeks to determine the distribution and genetic behavior of a group of related chemical substances in the pines. Its method consists in analysing the turpentine of each species and of hybrids. Most species have now been covered and more than twenty papers have been published on the results of some of their taxonomic implications. These results seem destined to be of very great importance in the various phases of pine-improvement work. Thus far they have provided guidance to the hybridization program; and an hypothesis to account for resistance and non-resistance of various species and hybrids to the western pine beetle is based on the presence or absence of a certain percentage of n-heptane in the turpentine of the trees. Another way in which the results will be very helpful is in classifying trees of doubtful identity.

During the past year, turpentine analyses were made of 12 entities: ponderosa pine from Arizona, the Black Hills, Colorado, and northern Idaho; Caribbean pine from British Honduras; Apache pine; spruce pine; Chihuahua pine; western white pine from northern Idaho; Lumholtz pine from Mexico; Table-Mountain pine; and Parry pinyon.

BARK BEETLE RESISTANCE IN PINES UNDER STUDY

Studies to determine why certain pines are able to resist bark beetles were continued by personnel of the Forest Insect Laboratory in cooperation with our forest genetics staff. Two hypotheses regarding the role of host-factors in bark beetle resistance have been evolved. One hypothesis relates to the quantity of oleoresin exuded by the tree during attacks by the beetles. Some studies have shown that although ponderosa pine is susceptible, certain individuals in a stand of trees are able to resist attacks of the beetle. The possibility that resistance is tied up with the tree's ability to exude oleoresin is being investigated. The other hypothesis relates to the chemistry of the tree's oleoresin. The Jeffrey x ponderosa hybrid has turpentine containing 25 percent n-heptane, and this hybrid is resistant to the western pine beetle. The Jeffrey pine parent also is resistant, and 96 percent of its turpentine is n-heptane. Ponderosa pine is highly susceptible to the beetle and has turpentine containing no n-heptane. Thus there is a strong indication that the presence of 25 percent or more of n-heptane in a tree's turpentine is toxic to the beetle. Verification of either hypothesis would place a powerful selective tool in the hands of the tree breeder.

BASIC RESEARCH NEEDED TO GUIDE TREE BREEDERS

During 1953 a manuscript on "Induction of polyploidy in pines by means of colchicine treatment" by Professor Sin Kyu Hyun, College of Forestry, Seoul National University, Suwon, Korea, was revised and submitted for

publication. Professor Hyun conducted his experiments at the Institute of Forest Genetics during 1952 with assistance from the Station staff. Some of the techniques tested by Professor Hyun produced various kinds of polyploids (pines having more than two sets of chromosomes). His work indicates that it may be possible to produce hybrids in which the chromosome set received from each parent has been doubled. Such forms, called amphidiploids, are fertile and true breeding. Pine hybrids generally are fertile but not true-breeding. Thus, by doubling the chromosomes of outstanding hybrid individuals, highly valuable new forms may be obtained.

Another fundamental study was made by Mr. Hsuan Keng, Professor of Botany, National Taiwan University, Formosa. He studied the needle characters of 40 of the Station's pine hybrids and their parents and prepared a report on his work. Data presented in this report, which is being revised for publication, will prove very helpful in studies of hybrids.

These two studies are but a small part of the basic research that could be done by making fuller use of facilities at the Institute of Forest Genetics. Research in various scientific disciplines is needed to broaden the Station's program of forest genetics research and accelerate the practical application of pine-improvement work. Physiological and biochemical studies are needed, particularly on the biology of reproduction. These studies could improve pollen-handling methods, enable us to improve rooting and grafting techniques, and enable us to effect early, regular, and abundant flowering in selected and improved stocks. Studies in various branches of morphology, particularly in cytology and embryogeny, are badly needed and many taxonomical studies await attention.

FOREST FIRE RESEARCH

The Station's work on control and use of fire in wildland management was of three types in 1953. One part was the continuation of original studies such as those in methods of appraising damages from fire and in ways of measuring fire danger. The second was in analyzing data and applying results from past basic research to current problems, and the third type of work, requiring a large part of staff time, was spent in assisting field men of the Forest Service and other agencies by means of publications, demonstrations, and technical advice. The fire research staff also contributed technical knowledge to the special cooperative project working in the Station under direction of the Washington office of the Forest Service.

FIRE DAMAGE EQUATIONS READY FOR FIELD TESTS

During 1953 equations developed for appraising timber and range damage caused by wildfires in northern California were tested for applicability, and a progress report was prepared describing the proposed method for appraising timber and range damage.

Erosion measurements were made on plots established on burned areas throughout northern California as part of the continuing basic research necessary to establish the basis for runoff-and-erosion damage estimates. Also, a system was devised for obtaining a single numerical rating of the physiographic features of a watershed which influence its stream flow and erosion characteristics. The rating is obtained from topographic maps and aerial photos and includes such features as stream length and stream slope. Through use of southern California data, these ratings were related to erosion potential. An analysis was then started to find ways to extend this relation to other areas.

INDEX SHOWS DIFFERENCES IN FIRE-SEASON SEVERITY

Analysis of the size and occurrence of fires and their relation to fire danger ratings was brought up to date with the addition of 1952 data to that already summarized for the period 1945-51. This gave a set of fire season severity indexes for California national forests from 1945 to 1952 which was published.

The severity index showed that for northern California 1945 was the most severe season of the 8-year period, with a severity index of 1.17 times the average, and 1952 the least severe, with an index .76 of the average. In southern California the high was 1.42 in 1948 and the low .72 in 1946. The severity ratings can be useful in answering such questions as "When are year-to-year variations in costs and accomplishments of a fire control organization due to variations in fire weather? When are the variations due to prevention and control action? To a combination of both?"

TIMBER CUTTING SHOWN TO INCREASE FIRE DANGER

Accelerated cutting and our inability to keep abreast of the slash problem on cutover lands have emphasized the need for a better understanding of the problems that exist on such areas. Methods of cutting the timber as well as the presence of slash itself can greatly increase the difficulty of fire control. Some of the effects of cutting systems were described for a committee of national-forest personnel meeting late in 1953 to draft its conclusions and recommendations from an 18-month study of slash disposal problems in the Sierra Nevada forests. Assisting the committee as technical advisors, our fire research workers pointed out that opening a timber

stand brings definite changes in the weather factors influencing fire behavior.

They made an analysis of data formerly gathered to determine the effect of stand density on wind velocity near the ground, litter moisture, and fuel temperature. Readings taken from tables showing the relative rates that fires spread under different combinations of wind, temperature, and moisture were interpreted to show the effects of stand density on the spread of fire. The analysis indicated that in a timber stand in which the tree canopy shades only 10 percent of the ground surface, surface fires will spread 3.5 times as fast as in a stand with a closed canopy:

Density of tree canopy, percent	Relative rate of fire spread
100	1.0
33	1.3
20	1.7
14	2.2
10	3.5

There was no appreciable difference between the 10 percent density and a completely open area.

The differences in rate of spread due to density of timber cause even greater difficulties in controlling fires than the tabulated ratios indicate. A fire that is traveling twice as fast as another produces about twice the perimeter in a given time. But the faster spreading fire also produces more heat and is therefore more difficult to halt; where the head of the slower fire might be stopped with 50 gallons of water, for example, the faster might require 200 or even 500 gallons.

Because there is no direct measure of the relative difficulty of control of surface fires moving at different speeds, it was assumed for purposes of this study that a fire spreading twice as fast as another is four times as difficult to control in the same fuel. In other words, it was assumed that difficulty of control varies as the square of the rate of spread. In these terms, surface fires in stands with 10 percent or less canopy density are 12 times as difficult to handle as fires in the same fuels in closed stands. Even in light fuels during high fire danger this differential could well mean that direct attack on a fire would be impossible.

It is evident that even with 100 percent slash disposal on large, cutover blocks, increased fire protection would be needed until the canopy is once more closed. Ideally, a balance between cutting systems and degree of slash disposal should be set up. What a timber operator must do to his slash in order

to minimize fire hazard will depend to a large extent on how much he has opened up the timber stand by his cutting.

CHEMICAL SPRAYS SUCCESSFUL FOR ROADSIDE BRUSH CONTROL

Plot studies and pilot testing of hormone-type chemical sprays on 600 miles of roadside brush on Shasta National Forest have shown the importance of complete coverage of leaves and stems from tip to ground level. The spray solution used included 2,000 ppm of 2,4-D and 4,000 ppm of 2,4,5-T; this was hand-sprayed to get complete coverage of plants in both an initial spraying and a follow-up treatment a year or two later. This procedure has proved economical in the long run--in 1953 that part of the 600 miles sprayed initially in 1949 and retreated in 1951 or 1952 had brush killed so that no further spraying will be needed for another two years or more.

We observed the operation of a boom-type sprayer used for the first time on the Shasta National Forest this year. The boom sprayer was developed in an effort to save manpower costs; but owing to the types and variety of plants and the many obstructions along rights-of-way on mountain roads, the boom did not produce adequate spray coverage to kill the roots of sprayed shrubs. Judging by the long range success of the hand-spray method, which gives 100 percent coverage of foliage and stems to ground level, the hand spraying should be used until a boom can be guaranteed to produce the same kill.

The brush spray manual, "The Use of 2,4-D and 2,4,5-T for Brush Control Along California Roads and Trails," was revised and now includes tables for determining low-volume spray quantities used on trails or wherever material must be packed in by mule, estimating guides for oil and water emulsion carriers, and check lists and purchasing directions for both chemicals and spray equipment.

All plots established in 1953 to test new formulations of 2,4-D and 2,4,5-T were carefully checked, but none showed better kill than the low volatile esters currently in use. New plots were located in the Klamath and Six Rivers National Forests.

Test plots were established on which the new weed killing and soil sterilizing chemical, CMU, was used. The material was applied in the fall of 1952 as a spray in amounts ranging from 10 to 50 pounds per acre. On rechecking the plots in the summer of 1953, we found that applications of 20 pounds or more per acre gave good results in killing annual plants and preventing the regrowth of weeds on the treated areas. However, very little kill of deep-rooted perennials had taken place. The permanence of the effect of CMU on the soil cannot be rated for several seasons.

The staff also compiled a fact sheet summarizing information on soil-sterilants, including application rates and methods, prices, and availability. This was done for dry kiln, lumber yard, and sawmill operators but should be of interest to other landowners with a need for cleared areas completely free of plant growth.

AIDS TO FIRE CONTROL COVER WIDE SCOPE

Among the jobs done to assist fire-control agencies was the recomputation of fire weather averages for national forests. Maintenance of the fire danger rating system used on the national forests of California requires that data recorded by weather stations in each fire danger rating area be summarized periodically and new "area averages" computed for the weather elements used in danger rating. This ensures that the averages will reflect as long a period of record as possible. In 1953 records accumulated during the past five years were summarized to bring the area averages up to date. These new data were sent out for use by fire control men in the field. Since these averages provide the base from which day-to-day protection needs are computed for national forests and ranger districts, periodic checking and recomputation are an important part of the continuous job of keeping protection facilities in balance with needs.

A handbook for fire weather station operators was compiled and made ready for publication. The material has been organized into three parts covering how and where to set up and equip a new weather station, how to adjust to locations which are not ideal, and maintenance and inspection standards for both new and old stations. Detailed drawings and photographs were obtained and complete lists of instruments and sources of supply were drawn up.

As part of our effort to discover better ways of training fire crews, a training program was worked up for increasing the efficiency of fire-fighting crews who use water. In April we hired four university students, who were then trained in operation of a tanker unit and drilled in the principles of fighting fire with water as outlined in the manual "Water Versus Fire." The student crew was then asked to design a program for training new crew men in the best ways to apply water on initial attack and mop-up. Their program was tested at actual training sessions. Then in June they were attached to the administrative branch of the Forest Service with a two-fold assignment: (1) teaching the principles of water use to fire crews and (2) continuing the development of training aids and methods. They were sent on a training schedule which reached each national forest in northern California and gave uniform instruction on efficient use of water to more than 100 fire crews. Throughout the summer, the student crew recorded the effectiveness of different

training facilities and the reactions of trainees to various training methods. This record constitutes a valuable guide for development of additional training tools.

SPECIAL PROJECT CONTINUES TO YIELD BASIC KNOWLEDGE

Current investigations of the special-project staff at the Station include basic research on the relation of atmospheric stability to fire behavior, the effects of ignition pattern on fire behavior, and the variation and effects of wind in the forest. These studies are of fundamental interest to forest management and fire control, but their application may require further analytical work.

There are indications that some fires which behave in unexpected ways are influenced by the gustiness of winds. In turn the degree of gustiness is associated with the variation of the temperature in the lower atmosphere, that is, the stability of the atmosphere. A preliminary study of possible effects of atmospheric stability on fire behavior was concluded during 1953. In this investigation an attempt was made to relate the erratic behavior of forest fires to some measure of atmospheric stability which could be computed from readily available weather data. Results of this study indicate that before measures of stability can be used to rate fire danger, several major problems must be solved:

1. More fundamental knowledge of the role of stability as an influence in fire behavior must be found through analytical research;

2. Better means of describing fire behavior must be developed;

3. Methods of estimating stability conditions must be perfected; and

4. Stability conditions as related to synoptic weather conditions must be investigated.

Pattern of ignition is one of the major factors affecting fire behavior. To explore some fundamental relationships of this phenomenon, 33 small plots covered with ponderosa pine needles were burned in cooperation with the California Division of Forestry. Fuel volume, size of plot, and ignition spacing were varied in a pattern designed to obtain the maximum information from a minimum number of fires. Data from these fires show that rate of fire build-up and fire intensity are increased as ignition density is increased. Interaction between fires made the rate of fire build-up and fire intensity greater than would be expected assuming no interaction.

Investigations designed to increase our knowledge of how

the wind blows in the forest were carried out during the year. Although information is available on the variation of wind with height in the open and deep inside a forest, little is known about wind variation in the transition zone at the edge of a forest. Accordingly, the edge effects were studied in a small isolated ponderosa pine stand. Wind speeds were measured at several heights in and above the stand and at various distances from the stand border. In this way curves showing wind "profiles" were obtained for highly turbulent, stable, and neutral atmospheric conditions. Results indicate that wind conditions typical of the interior of an extensive forest were developed 250 feet in from the stand edge. At this point wind velocities were reduced 50 to 70 percent below those in the open. The reduction was about 60 to 70 percent under turbulent daytime conditions, and about 50 - 60 percent under stable nighttime conditions.

Three coordinated studies have been made in connection with the problem of tree breakage due to wind. One study measured the aerodynamic drag of tree crowns of five coniferous species. The results enable determination of crown drag over a range of wind velocity sufficiently high to cause tree breakage under steady wind. Another study determined the force and deflection necessary to break tree stems under static loading, for ponderosa pine and loblolly pine tree stems between 10 and 32 inches in diameter. Stem diameter and height, stem form, and position of loading on the stem were determined to be the critical factors affecting deflection and breakage. Thirdly, studies of the heights, diameters, and weights of all parts of tree stems and crowns produced curves from which crown weight can be predicted from the height of crown and diameter at base of crown. Results of these three studies show how and where wind forces are applied to tree stems and indicate the magnitude of forces in the tree stem which resist wind. The results will also indicate the stem form and crown characteristics which the forest manager can work toward to minimize windthrow. Results of stem and crown analyses can be used to predict the amount of slash that will be produced under different cutting methods.

FOREST ECONOMICS

Two separate but closely related inventories of California resources make up the Station's current program in the field of forest economics. One task is the Forest Survey, a part of the nationwide study of the Forest Service to determine the location and extent of our forest land, the volume and condition of standing timber, the rate of growth, the rate of cutting, and the effect of losses from fire, insects, and

disease. During the past several years, information has been collected by means of aerial photos and measurement of timber stands on more than 4,000 sample plots distributed over the forested portion of the State. The Survey staff is now compiling and analyzing the large volume of data collected and is preparing reports on the findings. The second inventory, a refinement of the Forest Survey, is producing a series of maps that show not only the kinds of vegetation, but also the soils on forest and range lands of the State. Some of this work is being done to help guide the management of national-forest land, and late in the year a cooperative vegetation-soil survey on private and state lands was reactivated under authorization by the State Legislature.

FOREST RESOURCES LISTED FOR WESTERN SIERRA NEVADA

Data for a report on the forest resources of the western slopes of the Sierras was compiled during the year. This region covers an area of 22 million acres extending from the San Joaquin and Sacramento Rivers to the crest of the Sierras. Nearly 6 million acres were classified by the Forest Survey as commercial forest land, that is, land bearing or capable of producing timber of commercial quality and not withdrawn for other use. More than half (57 percent) of the commercial forest area is in public ownership, chiefly national forests. The total volume of sawtimber is 124 billion board feet (International 1/4-inch rule). White and red fir make up nearly one-half the total volume, ponderosa and Jeffrey pine about one-fourth, and sugar pine and Douglas-fir each about one-tenth. Nearly two-thirds of the volume is in public ownership. The annual growth after deducting mortality losses amounts to 1.3 billion board feet, or an average of 221 board feet per acre for all commercial forest land. Timber cutting in 1951 removed 1.8 billion board feet from forests of this area. Publication of detailed statistics is planned for 1954, in a report similar to the one issued in 1953 for the Redwood--Douglas-fir subregion.

RISE OF LUMBER INDUSTRY SHOWN IN "CENTURY" REPORT

The Survey staff also published a compilation of lumber production records for California and Nevada from the gold rush days to the present time. This report, published under the title "A Century of Lumber Production in California and Nevada," has been very popular and has brought letters of appreciation from trade associations, lumber companies, libraries, schools and persons interested in the development of the lumber industry in the west. Compiled from early Census records and for more recent years from data collected jointly by the Census Bureau and the Forest Service this report gives detailed information on the development of this important industry. Of particular interest is the rapid expansion of production in recent years (fig. 2). From 1849 to 1945

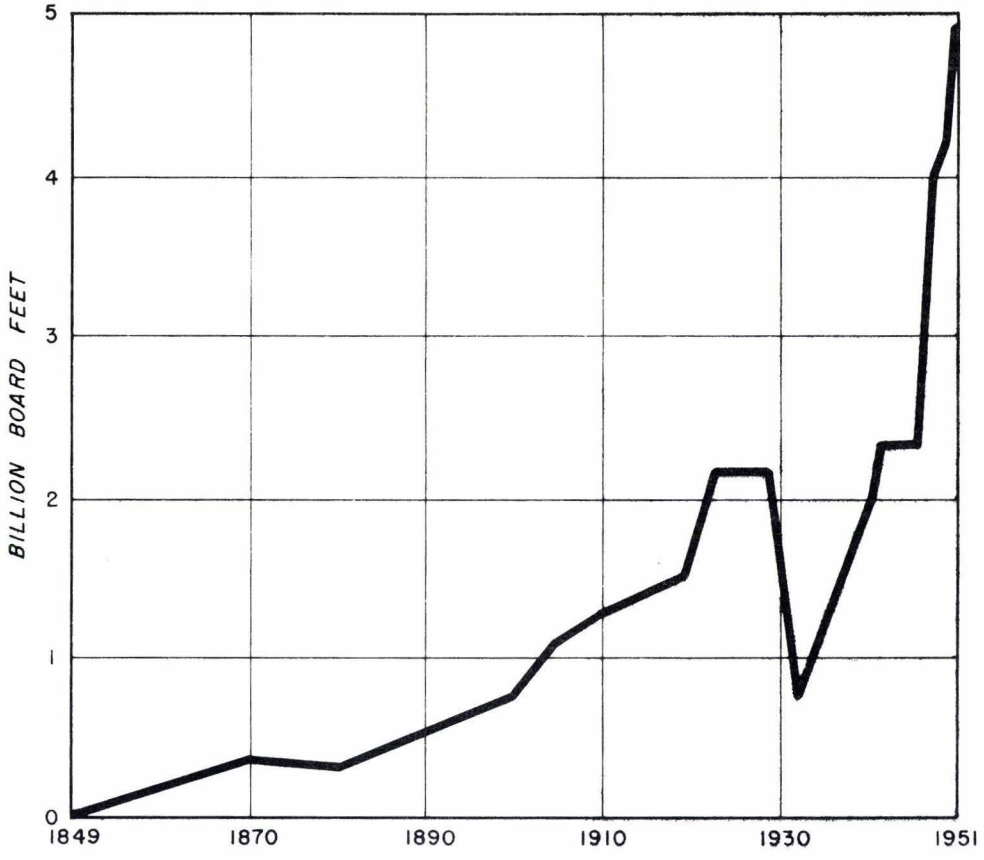

Figure 2.--Lumber production in California has more than doubled since 1945.

production had gradually increased to an annual volume of slightly more than 2 billion board feet. Since 1945, however, production more than doubled, reaching a total of nearly 5 billion board feet in 1951. The production of Douglas-fir increased more than four times (from 373 to 1,611 million board feet) during this 6-year period, making it the leading species in lumber production.

OWNERSHIP REPORT ISSUED FOR COAST RANGE AREA

Another major report issued during the year was titled "Ownership and Use of Forest Land in the Coast Range Pine Subregion of California." This report covered the findings of a joint study by the Bureau of Agricultural Economics and the Forest Survey on the ownership of forest land in the eastern portion of the North Coast Range. The study found two distinct patterns of forest land ownership and use in this area. In the northern part of the subregion much of the forest land is publicly owned and private holdings are generally large. Timber

operations and livestock ranching are major uses of land. The large holdings have made possible the development of management plans for the continuous production of timber. In the southern part most of the forest land is privately owned, holdings are small, and the pattern of use is complex. Farming, recreation, and residence are primary uses. Although the forests here are a significant part of the economy, production of timber is of secondary importance to the other major uses of land.

STATISTICS ASSEMBLED FOR NATIONAL TIMBER REVIEW

The Survey staff has also been assembling statewide statistics for the national Timber Resource Review. This review is one of the Forest Service's periodic reappraisals of the forest situation in the United States. It is designed to bring together the best available information on the timber resources of the country and the current and prospective timber requirements as a basis for reevaluating the forestry needs and planning a forestry program for the future. Most of the information on forest area, ownership, timber volumes, growth, and drain will be obtained from Forest Survey findings at the several forest experiment stations in the country.

The forest resource data for California are being compiled for use in both the Timber Resource Review and the Forest Survey reports for the state as a whole. To meet this dual objective, estimates of timber volume in the Redwood--Douglas-fir subregion have to be adjusted. Heavy cutting has occurred since 1948, when this subregion was inventoried. The adjustment is being made by examining timber stands along randomly selected sample lines in the area, to determine the changes that have occurred since 1948 as a result of cutting and fire. The data from these sample lines provide a basis for estimating the changes for the entire area. Preliminary results indicate that the volume of standing timber in this subregion has been reduced 7 billion board feet in 5 years, a reduction of about 1 percent per year. In the other subregions of the State, the date of inventory has been later or the volume of cut has been small so that adjustment of Survey inventory figures to bring them up to date will not be necessary.

STUDY MAKE TO DETERMINE AMOUNT OF LOGGING RESIDUE

As part of the summing up of timber resource information we also carried out a field study to determine the amount of sound wood felled or damaged in logging and left in the woods unutilized. Thirty plots were laid out on active logging operations. On these the volume of timber removed and the volume left or destroyed in logging were recorded. The results indicate that in the Pine Region utilization was very close to Survey standards of merchantability; about 2

percent of the sawlog portion of trees cut or damaged was left in the woods. In the Redwood Region about 17 percent of the cut and damaged sawlog material was left. A large part of this volume consisted of top logs of Douglas-fir that were left because of unfavorable markets for low grade lumber that would have to be cut from these logs.

Besides the residue of sound sawlog material, a large volume of topwood, limbwood, chunks, and cull logs was left on the ground following logging. Much of this material is suitable for pulpwood or other fibre use but has no market at the present time.

To complete the picture of resource use, data were also collected on the 1952 production of veneer, pulpwood, poles and piling, shingles, and other commodities. Lumber production estimates were obtained from the Bureau of the Census, trade associations, and the California Division of Forestry. These data will provide the basis for determining the total volume of timber cut in California in 1952.

VEGETATION-SOIL SURVEY AIDS NATIONAL FOREST WORK

Vegetation-soil surveys were made for two areas in the Mendocino National Forest. One area, 75,000 acres in Colusa County, was financed entirely by the California Region of the Forest Service. The other area, 240,000 acres in Glenn County, was financed in part by the Forest Service and in part by the University of California. This work was done in connection with an overall soil survey of Glenn County that the University is conducting. Mapping vegetation and soil concurrently in the National Forest was a new departure for the University, and the University soil scientist assigned to the job had to be trained in techniques of mapping vegetation types and timber sites.

Besides participating in this mapping program, the Station provided consulting services and soils training for national-forest workers. For these assignments, the California Region financed a vegetation-soils specialist on the Station staff during the last half of 1953. Consulting services, divided between six national forests, included:

1. Participating in a reconnaissance of a river basin, especially to help determine soil erosibility under logging, road-building, or other uses.

2. Making vegetation-soil reconnaissance of three burned areas so as to rate the soils as to erosibility and productivity for grass and to help recommend erosion-control measures.

3. Making vegetation-soil surveys of eight different areas where national forest managers are studying ways to convert brushlands to other types of vegetation.

4. Conducting short training sessions on forest soils for rangers and staff personnel on one national forest.

5. Checking successful grass seedings and tree plantations to relate the degree of success to kind of soil.

A special three-day session was held for the supervisors of all California national forests. Primary objectives were to acquaint the supervisors with the kinds of soils and behavior characteristics of soils found in national forest areas, the techniques of soil identification, and the uses to which soils information is being put on the Mendocino National Forest. At the close of the session, the supervisors recommended that the California Region continue to support vegetation-soils surveys for the national forests as available funds permit.

STATE COOPERATIVE PROJECT REACTIVATED BY LEGISLATURE

The 1953 State Legislature authorized a long-range program of vegetation-soil mapping aimed at covering an additional 19 million acres of tree and shrub covered wild lands outside of the national forests. Assembly Bill No. 672 that authorizes the work states that, "The State Forester may enter into agreements with any agency of Government, including the University of California, the Federal Government, and with any person, firm or corporation, for the purpose of engaging in cooperative soil, vegetation, and forest surveys." A companion Assembly Bill No. 673 appropriates $77,000 for fiscal year 1954, "to be expended by the State Forester for purpose of engaging in cooperative soil-vegetation surveys on the forest, watershed, and range lands of California."

The first step in carrying out the provisions of this legislation was the drawing up of a three-way master agreement between the State Department of Natural Resources, the University of California, and the Station. Under this agreement the Station assumes responsibility for the mapping program, including compilation of the data, and publishing of maps and reports. The Station also assumes general coordinating responsibility. The University assumes responsibility for laboratory and greenhouse studies of soils to aid in characterizing the soils and in interpreting their uses. Also, the University assumes responsibility for collecting supplemental data for range purposes. The University participates in inspections for maintenance of accepted standards of soil survey work, and in the establishment and correlation of soils and other classification units, so that the work will be accepted as a part of the national soil survey program.

Following approval of this master agreement, a separate agreement between the State and the Station was drawn up to allocate funds for fiscal year 1954. This was approved in November, and by the year's end the Station had organized a professional staff of 8 foresters and 4 soil scientists to carry out its contract. Four of the foresters will work on the project for 6 months while on leave of absence from their regular jobs in the State Division of Forestry and the lumber industry. By the end of the year the Station had also developed plans for training sessions and for starting field work early in 1954. Surveys will be conducted simultaneously in the foothills of three counties--Lake, Glenn, and Tehama. Lake County field work is scheduled for completion by June 1954, since most of the County has already been mapped. In Glenn and Tehama Counties the State cooperative vegetation-soil survey will be integrated with county-wide soil surveys that the University of California has under way. This integration means that the University of California will modify its work so that its men as well as those of the State cooperative project will map both vegetation and soils in wild land areas.

FOREST UTILIZATION SERVICE

Production of forest products in California continued at a high level during 1953. Lumber production probably was a little under the record 5 billion board feet cut in 1951. Plywood and veneer production increased moderately over 1951 because of new plants which came into production during 1953. There were no major additions to the pulp industry in the state, but there was important progress in the use of sawmill residues for pulp. In addition, other changes in wood utilization are developing from the introduction of fiberboard in the packaging of agricultural products.

The high level of activity in the forest products industries, together with increased interest in more intensive utilization, have brought numerous inquiries to our Forest Utilization Service Unit, from both local and out-of-state industries. Prominent among the inquiries were requests for information on seasoning methods, on properties and treatment of wood, on use of wood waste for molded products, and on possible uses of local hardwoods.

FIBER CONTAINERS CHANGE AGRICULTURAL PACKAGING

The first major change in decades is taking place in methods of packaging agricultural products. For many years the standard container for field crops and for citrus has been the sawed wood box. Within the past year or two, however, the corrugated fiberboard container has made

substantial inroads in this field. By employing a vacuum precooling system and car-icing methods by which the fiber boxes do not become wet, it has been found practicable to ship lettuce in fiber containers. Also, fiber is coming into use for shipment of lemons in containers that hold one-half the volume of the standard wood box.

To meet this competition two plywood plants are converting to the manufacture of paper-covered veneer for lightweight, low cost containers. Use of paper-covered veneer may in the long run broaden wood utilization, since the veneer may permit production of lower cost containers using some species and qualities of timber that have been difficult to market as lumber. At present, however, the change away from sawed wood boxes and crates is quite serious for some of the manufacturers of sawed shook who may not be able to convert to a lower cost container. It will also have some effect on box lumber markets.

We are working with the Forest Products Laboratory at Madison, Wisconsin, on a study of nailing characteristics of thin shook, particularly white fir, in an effort to improve the performance and usefulness of this material. It is hoped to include different types of nails, since they may have quite an influence on the splitting of shook when the boxes or crates are assembled.

CHIP PRODUCTION INCREASES USE OF PLANT RESIDUES

The production of pulp chips from sawmill slabs and edgings is reaching substantial volumes. Sawmills have begun to install mechanical barkers and one of the major redwood mills has installed a hydraulic barker and a chipper. Not only does this permit the production of clean chips from the barked slabs, but some operators feel that they are able to do a better sawing job since the sawyer has a better view of the log and the knots and other defects.

One of the roofing felt mills in southern California has changed over to the use of industrial wood waste instead of round wood as a source of fiber. Solid blocks of wood are put through a hammermill to reduce them to particle size before going to a defiberator. Another mill plans to get a substantial part of its fiber from chips produced by a sawmill just going into production near San Bernardino, California. This will mean a haul of about 70 miles instead of the 700 mile haul for the chips they have been using.

The Forest Utilization Service Unit at the Station has been conducting a plant residues survey in the state as a part of the national Timber Resource Review. It is expected that this survey will provide needed and useful information on the volumes, forms, location, and availability of residues. The

use of sawmill residues is already having an influence on the wood procurement policies of fiber-using plants. Better information on residues should have a further effect in broadening the utilization base without increased drain on the forest resource.

Apparently there are large volumes of slabs, edgings, and trim at sawmills and of solid wood waste at box factories that could be used in the form of fiber or particle board products. In the northwestern part of the state large volumes of water run into the ocean annually. Because of the low summer stream flow, however, establishment of fiber-using industries requiring water may depend on construction of reservoirs to assure a more regular flow. The Sacramento River carries a large volume of water throughout the year and with present-day techniques in the pulp and paper industry could probably support fiber-using plants without excessive pollution. Using at least part of the large volume of industrial wood waste in southern California will require economical processes for making fiberboard products with little water or for molding the fiber into useful objects. These processes also would be useful in other parts of the state where water supplies are not equal to the needs for water.

The increasing interest in diverting some of the presently worthless wood residue to useful purposes has resulted in increased use in agriculture. Some sawmills are now selling most of their surplus for stock and poultry bedding and for use in nurseries. To help find additional uses, the Bureau of Plant Industry, Beltsville, Maryland, has undertaken a study of wood and bark residue as a soil amendment. Samples of wood and bark of redwood, sugar pine, white fir, California red fir, and incense cedar have been sent to Beltsville for inclusion in this study.

WOOD PROPERTIES STUDIED IN YOUNG PONDEROSA PINE

The large volume of lumber now cut from second-growth or young-growth ponderosa pine is distinctly different from lumber cut from the old-growth timber. The hard, dense bands of summer wood in the wider annual rings of the young-growth timber makes this wood much harder to machine and season.

The Forest Products Laboratory has undertaken a study of the young-growth ponderosa, starting with samples from central Oregon. These studies were completed during 1952 and similar samples were collected in California during 1953. Six trees were selected from each of three areas of the best growing site (Site Class 1), representing three degrees of stocking. Two trees were selected from each of three crown classes and four or five test specimens were cut from each tree. These, together with three 8-foot bolts of knotty pine for a veneer-slicing study, made up a shipment of 182 pieces.

Sample material will be collected from at least one other site class within the commercial range of the species to complete the study of wood properties in young-growth ponderosa pine.

DRY KILN ENGINEERING SEEKS BETTER PERFORMANCE

Fewer large batteries of dry kilns were built in California this year than during the past several years, but several smaller ones were completed and additions were made to existing kiln facilities. The competition for kiln construction business appears to be increasing, resulting in somewhat better values to the buyers.

Three aspects of kiln engineering received special emphasis: (1) cheaper and more effective air circulation systems; (2) humidity control, both in the conventional steam-heated kilns and the direct-fired kilns, and (3) control of corrosion of metal parts used in dry kiln construction.

New metals, such as stainless steel and aluminum, are being tried. Associated with this search for more corrosion-resistant metals is the continued search for better protective coatings for the black iron and cast iron commonly used. The best protection appears to be through periodic swabbing of metal parts with used oil to which powdered graphite has been added and by keeping free water from condensing on metal parts.

DRY KILN CLUBS AID WOOD UTILIZATION

The several associations and clubs made up of dry kiln operators and others interested in lumber drying have carried on a full program throughout the year. These meetings are doing much to "encourage and promote more efficient air drying and kiln drying practices to increase profits, decrease waste, and more fully utilize our natural timber resources," as stated in the by-laws of the Central California Dry Kiln Club. Four such clubs in California have held 22 meetings with an attendance of over 700 men. One hundred and sixty-three men attended the annual meeting of the western clubs held in Boise, Idaho, including 35 to 40 from California. The Station's Forest Utilization Service unit works actively with the California clubs and helps to arrange for speakers.

The Redwood Seasoning Committee, one of the four clubs in California, will be host to the annual meeting of the combined western dry kiln clubs in 1954 and has already made extensive preparations. It is scheduled for May 13, 14 and 15 in Eureka. This meeting brings together kiln operators and others interested in lumber seasoning from all the western states.

STORAGE AND SEASONING STUDIED AT NAVAL DEPOTS

During the year the study of lumber storage and seasoning practices at representative naval depots throughout the country was completed by a team of experts from the U. S. Forest Products Laboratory. The Oakland Naval Depot and the Annex in Stockton were included in the study. Suggestions and recommendations, based on the results of the study, have improved the lumber storage and seasoning at naval stations. We made an additional study at a naval base in southern California and assisted the Laboratory personnel in their work. The study is summarized in a Forest Products Laboratory report.

SEARCH CONTINUED FOR SPECIAL SEASONING METHODS

The search goes on for a faster, cheaper, less damaging way to season wood. Air drying and kiln drying methods or a combination of the two, are now perfected so that losses during seasoning are reduced to a minimum. The speed (and cost) of drying now are balanced against quality or freedom from drying defects. Improvements in equipment and operating procedure may shave the present drying costs, but no drastic change in the conventional methods is likely.

Any major change will come with an entirely new approach to the drying problem, probably from the field we now class as "special seasoning methods." Examples are solvent seasoning, vapor drying, drying by vacuum, or by centrifuge.

Four special drying processes have been developed or promoted in California. None is as yet in commercial use. The common reason is that the technical soundness of some has not been demonstrated fully nor has it been shown that they can compete with conventional air drying and kiln drying methods on a cost basis. Under certain special conditions one or more of these processes may find a place, but none appears to have wide-spread application in the industry.

Two special seasoning methods recently developed in Europe may find limited application at small operations in California. One employs very high temperatures. The second utilizes very high rates of air flow attained by rotating the lumber instead of using fans to move the air. Further testing of these methods under conditions found in our industry is necessary before there is likely to be wide-spread acceptance.

CALIFORNIA HARDWOODS TESTED FOR TURNINGS

A commercial wood-turning plant in New England turned a variety of patterns from squares of four California hardwoods: tanoak, madrone, golden chinkapin, and California-laurel. The turnings were made to compare these woods with the hardwoods usually used, such as white birch, beech, and maple.

A preliminary report indicates the madrone turns very well and could be used for commercial turnings where its strength properties and color are favorable. The laurel also turned well, as was expected from the experience of the several novelties manufacturers in California and Oregon now using this species. Chinkapin and tanoak showed up less favorably on the type of lathes used.

Similar turning squares which we furnished for factory trials were turned on commercial lathes of the gang-cutter head type at three plants in Los Angeles. All four species turned well on this type of machine, particularly the madrone, which compares favorably with the Japanese birch currently being turned. The tanoak also showed up well, indicating there is a very real opportunity for utilizing some of the native hardwoods for this purpose.

RANGE RESEARCH

Several range research findings which shaped up during 1953 shed new light on two old questions: How can range lands of low fertility be rebuilt? and how can high forage yields be assured? Completion of years of field tests of many grasses and legumes, for example, has revealed the few that rate better than the native species. Judicious fertilization has been established as a sound way to boost foothill grazing capacity. Chemical control of two new range weeds appears very promising. With the exception of studies on game ranges, most of the work in the fields of reseeding, fertilization, and weed control will be directed in the future by the Agricultural Research Service, but we feel sure the studies reported here will be continued in close cooperation with the Forest Service. In other fields, we found some new clues on brushland improvement and on the game browse restoration problem. And the start of forage betterment was conspicuous on the first unit of a full-scale allotment test of a new grazing system for mountain bunchgrass ranges.

BEST GRASSES REVEALED FOR MOUNTAIN RANGE SEEDING

Intermediate wheatgrass has produced the highest yields of forage, in a 5-year test of eight promising grasses, on the Lassen National Forest. The test area was located on well-drained sagebrush-covered land in northeastern California, at an elevation of 5,600 feet.

Excellent persistence of intermediate wheatgrass was also shown on a similar area seeded in 1946 to 29 different grasses in duplicate field-scale plots. On these plots the control of weedy plants was only fair and the soil and moisture qualities of the site below average. The area has been grazed

for the past four years. Here, intermediate wheatgrass, smooth bromegrass, and crested wheatgrass have demonstrated ability to thrive under grazing and to provide adequate density and soil-protective cover. Several other grasses did not have an adequate stand in 1953, the seventh year of the test. Among the unsatisfactory grasses were: slender wheatgrass, mountain brome, blue wildrye, nodding wildrye, cereal rye, Idaho fescue, Russian wildrye, and green needle grass. The first five of these grasses were short lived; the stand diminished after the third year. The last three gave poor initial stands and have been inadequate throughout the test.

Until grasses such as tall wheatgrass, western wheatgrass, and meadow foxtail were tested, meadow sites where soil may be flooded three to eight weeks in the spring and drainage is slow were not considered suitable for seeding. Now these areas are proving to have the same high potential capacity for production of forage as some of the better drained lands. Ridging the soil in preparing for seeding, as reported last year, has helped improve drainage and, consequently, grass establishment and forage production. Experiments were started on adaptation of legumes for use with the grasses on these sites, on methods of controlling coarse rushes to permit grass establishment, and on the best methods and species for use on alkaline soils.

Some grasses were benefitted, others were not from applications of ammonium nitrate, in experiments in northeastern California. Highest response was obtained with such high-yielding grasses as tall wheatgrass, intermediate wheatgrass, and pubescent wheatgrass. No increased yield resulted from this fertilizer treatment applied to crested wheatgrass, western wheatgrass, smooth bromegrass, nor from a check plot of fertilized native grasses which included Idaho fescue, western needlegrass, and bottlebrush squirreltail. Grasses appear to differ in their nitrogen requirements. More experimental work is needed on time and rate of applying nitrogenous fertilizer to determine and evaluate fully the practical value of range fertilization on these high summer grazing lands.

Hybrid grasses are being tested in an attempt to find superior plants for range seeding. A cooperative test has been started with bluegrass hybrids obtained from plant geneticists of the Carnegie Institute and rye hybrids from the University of California. Field tests have also been started on new legumes from foreign sources to determine their suitability for range seeding on high summer ranges. Testing of this kind requires several years, both in nursery rows and field plots, before a new forage plant can be made available and recommended for large-scale use.

PROGRESS RECORDED IN WEED CONTROL

Results of our experiments in chemical control of three species of sagebrush and of buttercup and other mountain meadow weeds, have been outlined in previous reports. This work has been extended during the past two years to other range weeds, woolly mules-ear and western false hellebore.

In experiments with sprays applied to woolly mules-ear during 1952, a standard solution consisted of 9-1/2 gallons water, 1/2 gallon diesel oil, and 2 pounds acid equivalent of 2,4-D. Killing effects observed in July 1953, from spray treatments in June 1952, varied for the different forms of 2,4-D, as follows:

Form of 2,4-D	Percent kill
Butoxyethanol (low volatile) ester	83.5
Butyl ester	83.1
Alkanolamine salt	74.3

Over half of the plants not killed were severely weakened by the action of the herbicide and some of these may die in 1954. More experimental plots, sprayed in 1953, should help answer two additional questions: (1) the value of additives to the spray solution to give better wetting of the leaf surface, and (2) the stage of plant development where selective herbicides are most effective.

Exploratory work in control of western false hellebore showed this vigorous perennial meadow weed is susceptible to 2,4-D. Spray applied June 15, 1952 gave 93.4 percent kill of plants when 2.6 pounds of acid equivalent of butoxyethanol ester of 2,4-D in 160 gallons water were used per acre. More complete experiments were begun in 1953 to test lower gallonage of spray per acre and different forms of 2,4-D. Also, different wetting compounds were added to penetrate the leaf surface, which in this plant is so slick that the spray solution tends to run off instead of penetrate.

FOOTHILL GRAZING TRIALS CLINCH VALUE OF FERTILIZATION

A preliminary report was prepared during 1953 on a grazing trial at the San Joaquin Experimental Range, in which the objective is to determine how application of sulfur-bearing fertilizers influence livestock and range management. The trial is conducted in cooperation with the Department of Animal Husbandry, University of California. The joint report covered the first fertilization cycle in two 40-acre pastures grazed by weaner steers during the summer and fall. One pasture was fertilized at a rate equivalent to 60 pounds of elemental sulfur per acre in 1949 and again in 1953.

The method of fertilization used in the grazing trials was developed in plot studies started in 1941, which showed an impressive increase in forage production from sulfur fertilization.

In the grazing trial, forage production in the fertilized pasture during the first cycle of fertilization was: 1949, no increase; 1950, marked stimulation of native clovers; and 1951 and 1952, increased production of both grasses and legumes. Over the 4-year period, 1949-52, fertilization increased grass production by 2,853 pounds per acre; legumes by 1,418 pounds; and miscellaneous forbs by 129 pounds. Production of filaree decreased by 646 pounds. The net effect was an increase of 3,754 pounds per acre in total herbage production over that in the control pasture. In terms of grazing capacity, this greater production in the fertilized pasture was estimated as equivalent to 119 steer months. Actual stocking of the fertilized pasture was only 49 steer months greater; as a result, average utilization of this pasture was lighter than in the control. The increase in steer gains resulting from fertilization was 22.0 pounds per acre in 1950, 16.2 pounds in 1951, and 19.0 pounds in 1952, as contrasted to approximately equal gains in the fertilized and control pasture in 1949.

Records of livestock diet and individual gains during the summer and early fall further indicate that the value of the dry annual-plant forage can be greatly improved by stimulation of native clovers through sulfur fertilization.

COSTS DETERMINED FOR SULFUR FERTILIZATION

In cooperative studies on larger areas totaling some 1,200 acres at the San Joaquin Experimental Range, a few different methods have been tested for applying gypsum and soil sulfur on rangeland. Commercial application with the large ground rigs used by some operators on agricultural lands can be an efficient way of spreading fertilizers on gentle to rolling rangeland nearly free of rocks and trees. In one test on 250 acres of such land, crude bulk gypsum was applied at 500 pounds per acre at a cost of approximately $1.50 per acre for spreading plus $1.50 for the gypsum.

A common drill-type spreader pulled behind a farm tractor is useful on land with occasional rocks and brush. For application of sacked material with a 10-foot spreader at the rate of 1-3/4 acres per hour, the cost was about $1.40 per acre. The cost of applying bulk material would be slightly higher. A more maneuverable farm spreader is the broadcaster hooked to the hydraulic lift on a small tractor. Using this rig for application of sacked materials the cost was from $0.70 to $0.85 per acre; handling bulk gypsum cost an additional 10 to 50 cents per acre. Cost of the fertilizer with either rig would add $1.80

to $3.30 per acre above the spreading cost, depending on whether soil sulfur, bulk gypsum, or sacked gypsum is used.

The small farm spreaders could not be used efficiently on steep or rocky land. The wheeled tractors cannot be used safely where any of the slope gradients are over 30 percent. For such land, spreading by airplane appears most feasible. In a test on 400 acres, the cost of applying soil sulfur at 60 pounds per acre was rather high because of a 6-mile ferry from the landing strip -- $3.40 per acre for the flight and ground crew plus $1.80 for the sulfur. The costs estimated from experimental work should be modified, probably reduced, as more commercial operators and ranchers gain experience in spreading fertilizers on rangeland.

MOUNTAIN GRAZING SYSTEM BOOSTS FORAGE PRODUCTION

During 1953 representatives of the livestock industry, several land managing, educational and Extension Service agencies, and the public viewed results obtained on the Harvey Valley demonstration cattle range allotment in its second year of operation. The purpose of the Harvey Valley range allotment is to provide a practical field-scale test of a grazing system that was developed by this Station over a period of several years at the Burgess Spring Experimental Range on the Lassen National Forest. This system was designed to improve and increase the grazing capacity of bunchgrass-type mountain summer ranges. It calls for subdivision of the range into five units and grazing and resting these units in keeping with the growth and reproduction requirements of the forage.

During the second year of operation of this system, increased yield and vigor of herbage and heavy seed production--the principal basis for increasing the density of forage--were obtained in the native forage stand. Approximately 300 acres of introduced grasses started by artificial reseeding were established and brought to a high yielding capacity within the general framework of the system without additional fences or special grazing management measures. Increased forage yield and high seed production was also obtained on approximately 1,700 acres sprayed with 2,4-D to release native forage species from competition by sagebrush. Satisfactory grazing use was made of all these areas. Enough forage was produced on the areas scheduled for grazing to carry the 500 head of cattle that were normally grazed on the range prior to the establishment of the demonstration allotment.

The results obtained to date are all positive and in line with the theory underlying the grazing system. They encourage the hope that the range can be improved and increased

in grazing capacity while it is efficiently grazed. A total of five years will be required to apply one cycle of rest and grazing treatments to all of the pastures, and to appraise effectiveness of the system as a whole. Careful records will be made of range improvement or deterioration and of the weight gains and other responses of the cattle.

BURNING TECHNIQUES STUDIED ON BRUSH RANGES

In connection with studies on the use of fire in range improvement, the Division of Range Research participated during the year with the School of Forestry, University of California, and with the Division of Forest Fire Research in preparation of guides for use of the area-ignition burning technique. The fire-storm effects created by area ignition, which can produce disastrous blow-ups under wild-fire conditions, can be used under control on a smaller scale for effective removal of undesirable brush.

This technique is intended to supplement, not to replace, methods presently used for burning brush on livestock and game ranges. Area ignition can be used under certain weather and fuel conditions unsuited to conventional line firing; e.g. the technique can be used to spread fire into a light wind, downhill, or through moist fuel. The area-ignition system of firing is particularly adapted to certain land-clearing problems on California brush ranges such as opening wide control lines, burning out hazardous sections of larger burns, conducting burns during weather situations when protective forces needed are small, and obtaining complete and consistent removal of woody material where this is desired. Area-ignition is not designed for use under conditions of weather and fuel that permit effective safe spread of fire from conventional line-firing, nor at times when fires will spot and run. Successful area-ignition burning is difficult and should be used only by persons who are fully familiar with the conventional use of fire on brushland.

FORAGE ESTABLISHED ON CLEARED BRUSHLAND

Good initial stands of several forage species were obtained during the 1952-53 growing season on cleared test areas in the chamise and mixed chaparral types on the Mendocino National Forest. In these tests, conducted in cooperation with National Forest Administration and the California Department of Fish and Game, the land was cleared by fire and by mechanical means. The good stands were attributed to favorable early and late rains and an exceptionally mild winter. The results are in contrast to spotty stands or failures obtained in previous tests of broadcast sowing on similar low production sites. Covering of the seed with a specially designed roller had no significant effect during this favorable season. Continued study of reseeding techniques is needed, however, to develop

more positive methods, and to help determine the ways to manage reseeded grass stands.

The most promising species in tests to date, including tall fescue, Harding grass, intermediate wheatgrass, soft chess, and rose clover, will be sown to establish an herbaceous cover on areas studied in future brush burning trials on foothill and lower mountain ranges.

In a test on burned-over chaparral in the timber zone on the Tahoe National Forest, first-year establishment of forage species was very poor--failures for most species and only scattered plants for the most successful. This is the first test in this type; considerably more study is needed to determine the causes of success or failure.

GAME BROWSE RESTORATION A DIFFICULT PROBLEM

In July 1952 we started a new study in cooperation with the California Department of Fish and Game. This project is aimed at the development of ways and means to reseed browse on big-game ranges. Broad-scale methods applicable mainly to rough, non-arable lands are needed. The first studies were started on deer winter ranges located in the semi-arid region east of the Sierra Nevada and Cascade Range. Here lack of adequate browse, combined with deep snows and cold weather, cause high mortality in the deer herds in some years. Bitterbrush is the principal browse species. Unfortunately, however, it has been greatly reduced over extensive areas of critical range by overgrazing, fire, and insects.

In the present work primary emphasis is being placed on bitterbrush, but other species--native and introduced--are being studied as well. Results from plantings made last fall and this spring, along with various site-factor measurements, have provided a better understanding of the browse reseeding problem and have pointed to some of the principal gaps in our information needed for developing reseeding methods.

CLUES TO SUCCESS IN BROWSE PLANTING

Of 11 browse species planted from seed in the fall of 1952 only bitterbrush germinated in quantity this spring. The seed of all the other species seemed to be affected by a dormancy that was not broken by one overwintering in the field.

An understanding of the germination behavior of bitterbrush seed was obtained from previous studies. These studies showed that germination of bitterbrush seed could be expected under the field conditions of the present tests. Similar information on the germination behavior of the other browse species is needed early in the program. Work is getting under way now on wedgeleaf ceanothus (Ceanothus cuneatus), a valuable game browse

species that presents different seed germination problems and different planting problems than bitterbrush.

Soil moisture measurements and bitterbrush seedling survival records indicate that the existing vegetation on the planting sites must be reduced to provide growing space and adequate soil moisture for new browse seedlings. Soil moisture was drawn off more rapidly and to a much lower level during the growing season under a heavy cover of vegetation than under a sparse cover. Under the heavy cover, where competition for soil moisture apparently was intense, mortality of bitterbrush seedlings was higher than under the light cover. Also, seedlings were much smaller--1.4 inches in height compared with 6.9 inches.

Reduction of the existing plant cover and preparation of the site for planting present some of the most formidable problems in browse restoration. Mechanical, chemical, and biological methods and fire will be tested for the purpose.

Deep plantings (1.5 to 2 inches) approaching the limit of seedling emergence, gave higher germination and earlier seedling survival than shallower plantings, in the case of bitterbrush. In shallow plantings many of the germinating seeds appeared to be killed by drying top soil. In this first trial, best results were obtained in the 1.5 inch plantings. The effect of planting depth is felt most during the period of emergence and initial growth. This coincides with the period of highest seedling mortality. Depth of planting, therefore, is highly important in determining the early mortality and survival of seedlings. Seedling survival later in the season is controlled mainly by the moisture in the soil below planting depth level.

In small-scale fall and spring seedings of bitterbrush exposed to rodents only 13 percent as many seedlings survived 28 days after germination as in similar plantings protected from rodents. These results indicate that rodents may greatly reduce seedling establishment and rodent control may be found necessary. Broader scale plantings, to check or modify these initial small-plot results, are next in order.

The species of rodents that were responsible for the results obtained have not been determined. They are believed to be mainly mice and kangaroo rats. Rodents generally ate the browse seeds but did no serious damage to seedlings. Some damage to well-established seedlings by rabbits was observed on one area.

Bitterbrush seedlings were obtained from both fall and spring plantings. The latter gave the better results. The possibility of spring planting which is indicated here provides

hope for getting browse established on some of the drier sites where conditions favoring germination and seedling establishment occur infrequently. Under these conditions fall planting is a definite gamble. With spring planting, however, seeding can be postponed for one or more years until suitable soil moisture and weather conditions occur. A knowledge of soil moisture behavior, site by site, is essential for a solution of the browse restoration problem.

FOREST AND RANGE INFLUENCES RESEARCH

Watershed management research by the Station's Division of Forest and Range Influences was concentrated on two types of activity. One was the program of field and laboratory studies in southern California. Here, on the San Dimas Experimental Forest, significant differences in water use were found between different kinds of vegetation; in the Los Angeles River watershed the first quantitative measurements were made of soil movement on steep slopes; and at the California Institute of Technology the testing of plants for soil stabilization continued. The second line of work was in analyzing data previously collected in California and elsewhere. Such analyses included study of erosion in burned brushlands and in logged areas, sediment production from watersheds, some hydrologic effects of forest litter, and factors influencing the water yield from the Sierra Nevada snow pack.

EFFECTS OF RECORD FIRES STUDIED IN SOUTHERN CALIFORNIA

Wild-fires in 1953 destroyed the brush and forest cover on about 170,000 acres of mountain watershed lands in southern California, setting the stage for severe floods. The normal summer and fall fire season was prolonged and intensified by severe drought, causing the greatest destruction of watershed cover by major fires since 1919. During the last week in December two large fires burned over more than 20,000 acres on the Angeles National Forest.

One of these December fires burned into Wolfskill and Fern Canyons within the San Dimas Experimental Forest. Nearly 500 acres of old-growth brush, oak woodland, and Bigcone spruce were destroyed in the upper portion of Wolfskill Canyon, a 1,530-acre tributary of the San Dimas drainage. About 50 acres of cover were burned in adjacent Fern Canyon. Records of rainfall and streamflow have been obtained for the last 18 years from Wolfskill Canyon and from other similar watersheds within the San Dimas drainage. Continuation of these records will provide a unique opportunity to determine the influence of the fire in Wolfskill Canyon upon flood flows and water yield.

The staff of the San Dimas Research Center was called upon repeatedly for assistance in connection with these fires. Advice concerning the seeding of fire-denuded watersheds was given in response to requests from the national forests and local agencies in southern California. The seeding is done to establish a quick cover that will provide some protection for the soil during the first few post-fire years, when the regrowing native chaparral provides little protection. About 35,000 acres were seeded by airplane and helicopter, mostly with black mustard, Italian ryegrass, or a mixture of the two. We have found the mustard-grass mixture superior to either plant seeded alone. Recent laboratory tests showed that both mustard and ryegrass germinate rapidly at the low temperatures characteristic of the rainy season in the southern California mountains. The mustard produces a wide rosette of leaves in its early growth stage, thus providing abundant protective cover for the soil surface. The ryegrass, at this stage, provides little cover. Later the mustard rosette is replaced by a tall stalk, and shielding of the soil surface is reduced. By this time, however, the ryegrass has grown into a thick mat which continues to protect the surface.

WATER USE COMPARED FOR GRASS, BRUSH, PINES

A plot study, now in its second year on the San Dimas Experimental Forest, indicates that there are differences in evapo-transpiration between soil covered with annual grass, oak-brush, and pine. Soil moisture has been measured periodically in three plots by means of electrical moisture indicators located at various depths from the surface to bedrock. On one plot, the original brush cover has been replaced with a dense stand of Italian ryegrass; another one, adjacent, remains covered with scrub-oak and other native brush; a third, nearby, is occupied by a 25-year-old plantation of Coulter pine. The soil in the three plots is similar in all but depth. The soil under the grass plot is about 14 feet deep, that under the oak-brush about 17 feet deep, and that under the pine about 10 feet deep. These depths are considerably greater than normal in these mountains.

The winter of 1951-52 had above-average rainfall, totaling 41.1 inches at the study areas. This rainfall was sufficient to wet the entire soil column of all the plots to field capacity. The next winter had subnormal rainfall, only 15.5 inches of rain being received. Most of this rain fell before January 1, 1953.

Some significant differences in soil moisture conditions under the three types of cover were recorded during the two years (fig.3). By February 1, 1952, the full depth of soil had been wetted to field capacity. By November 1, 1952, the pine had reduced the soil moisture to or below the wilting point at all

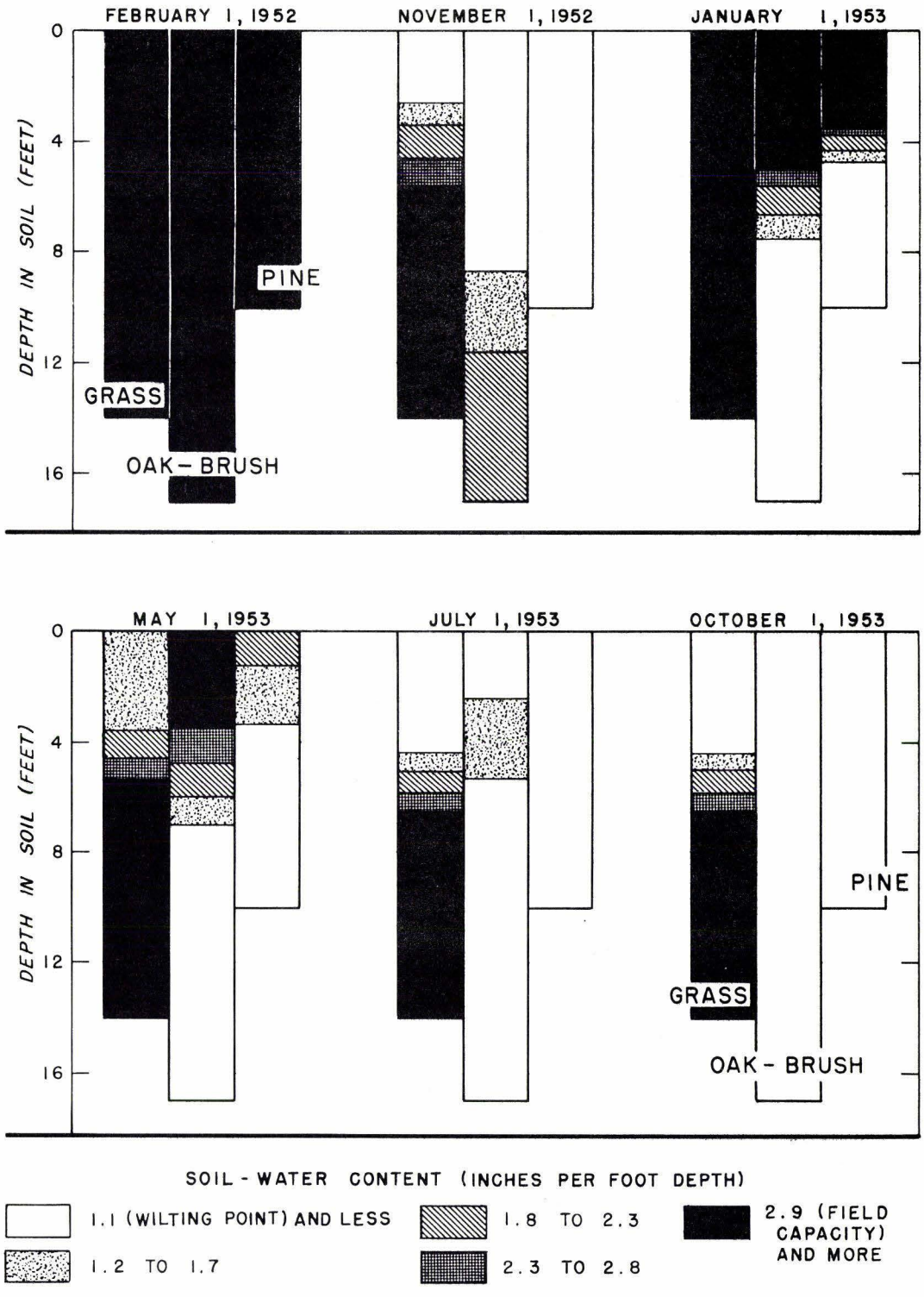

Figure 3.--Seasonal soil-water content is influenced differently by covers of annual grass, oak-brush, and pine.

depths in the soil; the brush had utilized all available moisture to a depth of 10 feet and some to the full depth of the soil, and the grass had dried the soil below field capacity only about 6 feet deep.

Between November 1, 1952, and January 1, 1953, the upper 6 feet of soil under the grass was again raised to field capacity, leaving the entire soil column there charged with water. The rains, however, were sufficient to bring to field capacity only the top 5 feet of soil under the oak-brush, and the top 3-1/2 feet under the pine. By May 1, after 4 months of light rainfall, the grass had utilized a large portion of the moisture stored in the top 5 feet of soil, the oak-brush had used but little of the moisture that had accumulated, while the pines had removed most of the moisture that was available. Two months later, on July 1, the grass had used little additional soil moisture, while the oak-brush had used almost all, and the pine all, of the available moisture in the soil. The next 3 months brought little change in soil water storage: the grass had used no more water, and the entire soil column under the woody covers was either at or below the wilting point. It is notable that soil moisture storage at the end of this year of low rainfall was nearly identical to storage at the end of the previous, high rainfall, year.

The grass growing on the San Dimas plots apparently utilizes water rather rapidly during the spring season within the upper 5 or 6 feet of soil, but it does not draw upon water at greater depths. The oak-brush uses little water in the spring, but water use continues throughout the dry summer and fall until the entire soil column is dried to the wilting point. The Coulter pine uses almost as much water in the spring as does the grass, but it dries the soil column to the wilting point earlier in the dry season than does the oak-brush.

Evidence of differences in seasonal water use between pine and scrub-oak has also come from the San Dimas lysimeter installation. Five lysimeters of this installation have for 8 years supported a pure stand of young Coulter pine. Five others are covered with a pure stand of scrub-oak. Both species have been found to utilize, yearlong, about equal quantities of water; that is, all the available water in the six-foot depth of the lysimeter soil. However, for the period from October 1 to April 30, evapo-transpiration in the pine lysimeters averaged, over a five-year period, 3.3 inches more than did evapo-transpiration in the scrub-oak lysimeters (table 4). The greater water use of the pines during the cool season was about balanced by greater water use of the scrub-oaks during the warm season.

Table 4.-Evapo-transpiration from 6 feet of soil, in scrub-oak and pine-covered lysimeters

Hydrologic year	Scrub-oak			Coulter pine		
	Oct.1 to Apr. 30	May 1 to Sept.30	Total	Oct.1 to Apr.30	May 1 to Sept.30	Total
	. . . . . Inches					
1948-49	3.5	11.6	15.1	6.8	7.9	14.7
1949-50	7.9	12.2	20.1	12.6	6.1	18.7
1950-51	5.0	6.8	11.8	8.1	1.8	9.9
1951-52	7.6	15.0	22.6	9.9	13.9	23.8
1952-53	8.5	8.6	17.1	11.4	2.3	13.7
Average	6.5	10.8	17.3	9.8	6.4	16.2

On deep soils, such as those of these plots and lysimeters, differences in seasonal and year-long water use by grass, oak-brush, and pine, have important implications for watershed management. The annual grass did not dry the entire soil column, but the oak-brush and pine did; hence less rain would be required each year to start percolation (which feeds springs and streams) from deep soil covered with this kind of grass than from deep soil covered with either of the other two kinds of vegetation. One would, therefore, expect less water yield from an area of deep soil covered with Coulter pine or oak-brush than from one covered with Italian ryegrass. Again, the grass and pine used water more rapidly during the rainy season than did the oak-brush. Withdrawal of water from the soil after a storm provides space in the soil to hold rain water during the next storm. The more rapid withdrawal of soil water by grass and pine could result in more storm water being retained by soil under these covers, less water draining from the soil into streams during large storms, and correspondingly lower storm flows in streams.

It must be pointed out, however, that contrasting results such as these are not apt to be obtained on the shallow soils that are much more common in the mountain lands of California. All three types of plants would use each year all the

available water in soil less than 5 feet deep, and much smaller differences in seasonal water use would be expected in shallow soil.

SOIL MOVEMENT ON STEEP SLOPES STUDIED

Erosion rates are high in the San Gabriel Mountains of southern California, even in long-unburned watersheds. This has prompted the Experiment Station to study the movement of soil on the steep slopes that prevail in these mountains; it is from these slopes that much of the sediment load of local streams is derived. A large part of the soil movement on these slopes takes place as creep or sliding rather than as water-caused erosion.

Soil movement is being measured on slopes in the Los Angeles River watershed to determine just how sediment reaches the streams. Half-round steel troughs are inserted flush with the soil surface on contour from the point of a ridge to a stream channel. These troughs catch soil and other material moving down the slopes above. Five such troughs, ranging from 68 to 431 feet long, were installed. They sample a wide range of slopes. At one extreme are the low-gradient slopes near rounded ridges. At the other extreme are slopes whose gradient exceeds the angle-of-repose; they extend above recently downcut streams and hence are termed rejuvenated slopes.

Soil moved into the catchment troughs during the past dry seasons of summer and fall at rates which ranged from 0.8 to 31.6 pounds per acre per day (table 5). This range is equivalent to 93 to 3,700 tons per square mile per year.

After the first fall rains soil movement rates decreased on the slopes. For example, the rate at the Lower Brown site during the early part of the rainy season was only 36 percent of the dry season rate.

The troughs were divided by wooden plugs into 20-foot segments, permitting study of the catch of individual segments in relation to characteristics of the contributing slopes above. During the dry season the trough catch at the Falls site was found to increase uniformly as the slope length increased. At the Upper Brown site, in contrast, the trough catch was about the same regardless of the length of the slope above. This difference suggests that soil moved in a different manner at the two sites. On the rejuvenated slopes of the Falls site the soil moved as a tumbling stream down the whole slope length. On the less steep slopes of the non-rejuvenated Upper Brown site the soil moved uniformly, step-by-step, and only that moving across the bottom step spilled into the trough.

Table 5.-Soil movement during dry season, on slopes in the Los Angeles River Watershed

Plot	Plot characteristics				Trough catch during dry season
	Trough length	Plot area	Aspect	Rejuvenated slope	
	feet	acres			lb./ac/day
Upper Brown Canyon	273	0.82	South	No	3.0
Lower Brown Canyon	68	0.72	South	Yes	31.6
Falls	431	1.27	North	Yes	4.8
Singing Springs #1	291	About 1	South	No	0.8
Singing Springs #2	200	About 1	North	No	1.2

TESTING CONTINUED WITH SOIL-STABILIZING PLANTS

Once the rates of soil movement on the five sites have been determined under existing vegetation, the vegetation on portions of each site will be changed to find out if the rate of movement can be reduced. Both native and exotic plants are being studied under laboratory conditions, in a search for species that will grow in these mountains and provide better soil stabilization than those now present. Plants of value for this purpose must be able to germinate and grow well during the cool part of the year, for this is the only time when plentiful moisture is available to them. Species that fix atmospheric nitrogen are particularly desirable because the mountain soils are deficient in this essential element.

The laboratory testing of non-native plants has continued this year, with seed sent by cooperators in various parts of the world. The testing is done in cooperation with the California Institute of Technology. In a controlled-environment laboratory the plants are germinated and grown under temperature and day-length conditions representative of winter, spring-fall, and summer in the local mountains. By simulating these field conditions in the laboratory the screening of likely species can be accomplished much more rapidly than by the use of field trials.

Plants tested during 1953 are grouped according to their temperature requirements as follows:

A. Species which grow equally well at all seasonal temperatures

Lotus mascaensis	Canary Islands
Lygeum spartum	Spain
Phalaris tuberosa var. stenoptera	California
Retama roetam	Israel
Pinus brutia	Turkey

B. Species favored by winter temperatures

None this year.

C. Species favored by spring-fall temperatures

Brassica nigra	California
Cytisus canariensis	Canary Islands
Melica imperfecta	California
Cneoridium dumosa	California
Sophora tetraptera	Chile
Cercis siliquastrum	Italy

D. Species favored by summer temperatures

Schinus dependens	Chile
Calycotome villosa	Israel
Cassia acuta	Chile
Zizyphus lotus	Israel
Spartium junceum	Italy

The plants listed above, and others tested earlier, are also undergoing tests for drought resistance, frost resistance, and ability to grow in the local mountain soils. Field plantings are being made of the most promising species as a final check on their suitability for testing on the soil movement plots.

FURTHER ANALYSIS MADE OF BRUSHLAND EROSION

Study of erosion in burned-over foothill brushlands continued this year with attention concentrated on lands north of the Tehachapi Mountains. Of 72 burned areas examined in this region during the rainy season of 1950-51, 67 had shown active and accelerated erosion when compared with nearby unburned areas. With erosion so obviously and generally accelerated by burning, it was necessary to find out how frequently one might expect a rainy season having storms as severe as, or more severe than, this one. Only by this means could we determine how unusual the eroding of burned lands was in 1950-51.

Rainfall data could not be used to determine the severity of rainy seasons in the foothill lands because raingage records there were too few. Good records of storm flows, however, were available for many streams rising on these lands, and these records could be used for the determination. Yearly maximum flows of 24 streams widely scattered over the area under study formed the basis for the determination. The peak flow records ranged from 11 to 30 years in length. Analysis of these records showed that yearly peaks at least as great as those of 1950-51 could be expected from once every 2 years along the east side of the Sacramento Valley, to once every 7 years in the northern Coast Range. These findings were particularly interesting in view of the fact that some of the large Sierra Nevada streams rising at elevations above the foothills produced the highest peak flows of record during the winter 1950-51. The analysis showed that for the foothill brushlands this winter was not as unusual as the flows of major streams would lead one to believe.

A significant sidelight of this erosion study has been the interest aroused by publication of a paper describing the erosion criteria that were used. Since publication in 1953 of C. H. Gleason's "Indicators of Erosion on Watershed Land in California" there has been an unusually heavy demand for reprints. Many requests have come from state and federal land-managing agencies, showing the need of field men for means of recognizing signs of erosion on wildlands.

HYDROLOGIC FUNCTIONS OF PINE LITTER EXAMINED

The layer of pine needles (the forest floor) covering the soil in pine forests catches part of the rain falling upon it, returning this part of the rain to the atmosphere by evaporation. The floor also shields the soil surface against the impact of raindrops, aiding the infiltration of water into the soil, and it acts as a barrier to evaporation of water from the soil. These functions of the forest floor were studied using data collected some years ago in a ponderosa pine forest near Bass Lake in the Sierra Nevada, and in lysimeters at Berkeley.

At Bass Lake the rain water evaporated from a floor 1 inch thick averaged 1.5 inches a year, a floor 2.7 inches thick lost 2.3 inches of water, and a floor 3.6 inches thick lost 2.7 inches. During the winter, when storms were frequent and the floors continuously wet, evaporation was about the same from floors of all thicknesses. Evaporation was negligible when the floors were covered with snow. During the drying period of spring and summer, when storms were infrequent, the floors gradually dried out and evaporation was greater the thicker the floor.

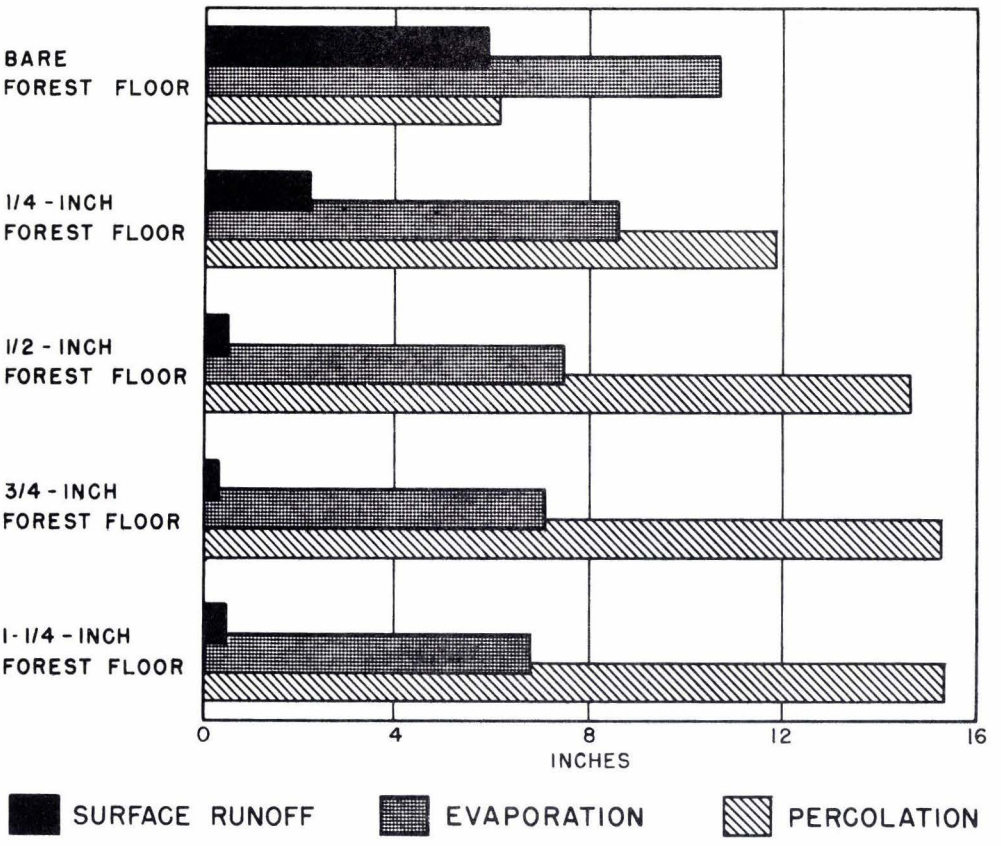

Figure 4.--Berkeley lysimeter data show how the forest floor influences rainfall disposition during the average rainy season.

In the Berkeley lysimeter study, surface runoff, evaporation, and percolation were measured in five blocks of soil, one bare and each of the others covered with a different thickness of forest floor (fig.4). This study showed two beneficial effects of the forest floor that offset the evaporative loss of water caught by the floor. Surface runoff of rain water was markedly less from the covered soil than from the soil with a bare surface, and evaporation of water from the soil was less where the floor was present than where the soil surface was bare. Percolation of water through the soil was, therefore, greater under a cover of forest floor than under a bare surface. This study also demonstrated that a great thickness of forest floor is not needed to provide effective control over surface runoff and evaporation. The soil under floors 1/2 to 3/4 inch thick yielded more percolation water than did the soil under a floor 1/4 inch thick, but about the same amount as did the soil under a floor 1-1/4 inches thick.

The results of these studies will appear in the Journal of Forestry, in an article titled "Effects of the Forest Floor on Disposition of Rainfall in Pine Stands", by P. B. Rowe.

METHODS STUDIED FOR REDUCING WATERSHED DAMAGES DURING LOGGING

Information on logging damages to watersheds, gathered in 1952 by a team of Station and Regional Office men, has been used in preparing a handbook of suggestions for minimizing such damages. The need for this study is indicated by the fact that approximately 200,000 acres of forest are logged-off annually in California. At the same time more than 100,000 kilowatts of hydro-electric power, and a proportionate amount of reservoir storage, are being developed in mountain streams to meet the power and water demands of our growing state.

Not all of the logged areas contribute equally to watershed damages, but the area of soil mechanically disturbed by logging roads, loading places, and skidways, averages more than 15 percent of the total logged area. Thus some 30,000 acres of land are changed each year from stable permeable forest floor to bare surfaces relatively impervious to rain infiltration and exposed to accelerated erosion. In addition, many miles of streams within and below the logged areas are polluted with silt or clogged with heavy sediments and logging debris. A portion of the sediments is ultimately deposited in reservoirs or contributes to the shoaling of the major rivers of the State.

While it was not possible, in this reconnaissance type of study, to measure or evaluate these effects, the general conclusion was reached that the aggregate of watershed damages throughout the State is much greater than is usually assumed. Further, in consideration of California's continuing growth in population and water needs, the situation is grave enough to challenge any complacent acceptance of such damages as being inevitable or justified by the need for wood.

Specifically the study has revealed that failure to follow well-known principles of road construction, and especially of drainage, is responsible for the greater part of the watershed damage in logging areas. Many cases were found where extreme erosion could have been prevented by some simple measure such as a water-break across a road or tractor trail. Bad location of roads, landings, and main skidways, has resulted in unnecessary damage. Numerous logging layouts have been efficient for the single purpose of getting out logs, but have caused heavy watershed damage. These findings emphasize sharply that careful advance planning must be applied to logging projects in mountain areas, and that the plans must provide for safeguarding watershed conditions as well as for extracting logs economically.

The handbook in preparation will show by photographs of actual field examples, good and bad practices in the location and construction of logging roads, landings, and main skidways, measures taken after logging to erosion-proof these disturbed areas, and the special care needed in salvage logging of burned areas.

SEDIMENT PRODUCTION OF LANDS EVALUATED

An analytical method was developed for estimating the erosion potential of land areas, by utilizing available data on the suspended sediment loads of streams. The study made use of data collected in watersheds west of the Cascades in Oregon while this Station had a flood control survey program.

The sediment load of a stream, when measured at its mouth, integrates the quantities of sediment discharged from all parts of the watershed above. With this kind of measurement the rates of sediment discharge from individual parts of the watershed remain unknown. From one watershed to another, the sediment loads of streams vary in response to differences in streamflow, topography, land use, and other factors. It can be assumed that within the parts of a single watershed there are similar responses. The method developed, employing multiple regression analysis, permitted evaluation of the response of sediment discharge to variations in streamflow, soil, topography, and land use. These responses were used to estimate how much of the sediment load measured at the mouth of a watershed was contributed by individual parts of that watershed.

One of the results of this study was a map of erosion potential prepared for lands in western Oregon under average land use conditions. Another was an evaluation of how erosion rates in this area vary from the potential rates in response to deviation of land use from average. The method can be used in other areas where suspended sediment measurements have been made in a number of streams, and thus should prove useful to land and water managers in many places. The results of the study will be published in the Transactions of the American Geophysical Union under the title "Suspended Sediment Discharge as Related to Streamflow, Topography, Soil, and Land Use" by H. W. Anderson.

FOREST INFLUENCE ON SNOW STUDIED

The winter snow pack of the Sierra Nevada, the Cascades, and the northern Coast Range supplies the greatest part of each year's flow of water in California streams. Research in the Wasatch Mountains of Utah and in the northern and central Rockies has shown that it is possible to exert some control over the water yield of the snow pack by opening dense stands of timber or creating windbreaks. No field research in snow pack management is currently under way in California, but the Station is analyzing snow pack data collected since 1946 by the

Corps of Engineers and the Weather Bureau at the Central Sierra Snow Laboratory near Soda Springs in the Sierra Nevada. When this analysis is complete we shall have evaluated some of the influences of forest condition upon snow accumulation and melt, and we shall know which influences require further study in laboratory and field.

Three years' data from five snow courses were analyzed in 1953, studying the relation between the rate of snow melt (including evaporation, because evaporation and melt could not be separated) and the amount of shade provided by nearby trees. Four snow measurement points were selected along each course, two with little shade and two with much shade. The amount of shade was expressed quantitatively as the duration of shading at each measurement point between April 1 and June 15 (the average melting period) multiplied by the amount of solar energy which would have impinged on the snow surface in the absence of shading. The average rate of snow melt for the 2-1/2 month period decreased as the amount of forest shade increased, the rate under full shade being about 60 percent of the rate in unshaded openings in the forest. The marked effects shown by this analysis suggest that other important influences of forest condition upon water yield from the snow pack will be found as the analysis proceeds.

PUBLICATIONS

Forest Management Research

Clements, V. A.
Possible means of reducing mountain pine beetle attacks in young sugar pine. 5 p. Research Note No. 89. May 15, 1953

Study shows that it may be possible to lessen build-up of beetle populations by removing the more susceptible trees and lowering stand density through commercial and non-commercial thinnings.

Fowells, H. A.
The effect of seed and stock sizes on survival and early growth of ponderosa and Jeffrey pine. Journal of Forestry 51(7): 504-507. July 1953.

Among nursery grown seedlings and transplants which had been graded into three size-classes, the "large" and "medium" grades produced most of the larger trees nine years after field planting. Seed size, however, did not affect tree size.

Fowells, H. A. and G. H. Schubert.
Planting-stock storage in the California pine region. 12 p. Technical Paper No. 3. September 1953.

Ponderosa pine and Jeffrey pine nursery stock can be stored under refrigeration for several months without serious effects on survival and growth after field planting.

Fowells, H. A.
Regeneration problems and research in California. 4 p. Misc. Paper No. 10. March 6, 1953.

A summary of the current situation and promising lines for investigation.

Roy, D. F.
Douglas-fir regeneration--a selected and annotated bibliography for use in California. 27 p. Technical Paper No. 1. May 1953.

Lists and annotates 84 publications based on research and observations of workers in the United States and Canada.

Roy, D. F.
Effects of ground cover and class of planting stock on survival of transplants in the eastside pine type of California. 6 p. Research Note No. 87. September 25, 1953.

Results of study show why tree planters should be taught to select the best spots--avoid vegetated spots, very stony spots, and heavy slash. Ponderosa and Jeffrey pine 1-1 transplants survived considerably better than 1-0 seedlings.

Roy, D. F. and G. H. Schubert.
K-screen seedspots. 2 p. Research Note No. 88. May 15, 1953.

First trials show that K-screens, a device for protecting tree seed from seed-eaters, require improvement before they can be generally recommended. Modifications are being tested.

Schubert, G. H.
Ponderosa pine cone cutting by squirrels. Journal of Forestry 51(3): 202. March 1953.

Squirrels destroyed 863 cones--93 percent of the crop from a single ponderosa pine tree.

Schubert, G. H.
A trial of three chemicals as rodent repellents in direct seeding. 2 p. Research Note No. 84. February 4, 1953.

Sodium fluoracetate ("1080"), red lead, and zinc phosphide did not hinder germination, but they failed as repellents on seed spots.

Tackle, D., and D. F. Roy
Site preparation as related to ground cover density in natural regeneration of ponderosa pine. 13 p. Technical Paper No. 4. October 1953.

Duff, slash, and vegetation were found to hinder establishment and development of tree seedlings in the eastside pine type of California. The effects became increasingly greater with time for the first 4 years. Proper site preparation aids both germination and survival.

Forest Genetics Research

Duffield, J. W.
Pine pollen collection dates - annual and geographic variation. 9 p. Research Note No. 85. March 3, 1953.

Gives data on pollen collection dates for species and hybrids at the Institute of Forest Genetics and for local species on the El Dorado transect of the Sierra Nevada. Also discusses the effect of weather on pollen-ripening.

Duffield, J. W.
It's the ancestor that makes the tree. American Forests 59(11): 37, 46-47. November 1953.

A general article on the possibilities of improving forestry through application of genetic principles and the urgent need for support of basic research on heredity of forest trees, physiology, entomology, pathology, etc., to make the application more effective.

Duffield, J.W. (By R.T.Bingham, A.E.Squillace and J.W.Duffield)
Breeding blister-rust-resistant western white pine. Journal of Forestry 51(3): 163-168. March 1953.

Outlines the program, describes methods and procedures used, and gives results obtained from a new international cooperative project to develop rust-resistant white pines.

Duffield, J. W., and F. I. Righter
Annotated list of pine hybrids made at the Institute of Forest Genetics. 9 p. Research Note No. 86. April 13, 1953.

Gives for 23 promising hybrids (1) common and scientific names, (2) information about their probable utility, and (3) recommendations respecting regions where they should be tested. Temperature and precipitation data for the Institute are presented, and the Station's policy regarding the distribution of its products is stated.

Iloff, Jr., P. M. and N. T. Mirov
Composition of gum turpentines of pines. XVI. A report on Pinus oocarpa and P. pseudostrobus var.oaxacana from Chiapas and P. cooperi from Durango. Journal of the American Pharmaceutical Association, Scientific Edition 42(1): 46-49. January 1953.

Gives methods and results of analysing turpentines.

Forest Genetics Research (Continued)

Iloff, Jr., P. M., and N. T. Mirov
Composition of gum turpentines of pines. XVII. A report on Pinus montezumae from Chiapas and P. oocarpa var. trifoliata and P. durangensis from Durango, Mexico. Journal of the American Pharmaceutical Association, Scientific Edition 42(8): 464-467. August 1953.

Gives methods and results of analysing turpentines.

Liddicoet, A. R., E. F. Kimbrough, and E. J. Carpender
Ponderosa pine plantation pruning. Journal of Forestry 51(4): 275-276.

Part of a 15-year-old plantation at the Institute of Forest Genetics was pruned to a height of 7 feet, using a pruning saw, an axe, and a gasoline-motored limbing saw. The relative efficiency of the three tools is discussed.

Mirov, N. T.
Chemical aspects of Diploxylon pines. Ztschr. f. Forstgenetic u. Forstpflanzenzuchtung 2(5): 93-96. 1953.

Discusses the relationships between the Diploxylon (hard or yellow) pines in the light of the chemistry of their turpentines and presents a classification based thereon. This classification differs somewhat from Shaw's classification, which is based on morphological characters. It also differs slightly from a revised classification based on hybridization results and proposed by Duffield.

Mirov, N. T.
Taxonomy and chemistry of the white pines. Madrono 12(3): 81-89. 1953.

Discusses the relationships between the Haploxylon (soft or white) pines in the light of the chemistry of their turpentines. Shaw's classification, which, based on morphological characters, gives species rank to 19 forms, is accepted with the reservation that 26 forms deserve species rank on the basis of the chemistry of their turpentines.

Forest Fire Research

Countryman, Clive M.
A pocket type humidity indicator for use in fire prevention and control. 1 p. Misc. Paper No. 12, May 1953.

Describes a chemical humidity indicator card for determining humidities up to 50 percent.

Forest Fire Research (Continued)

Countryman, Clive M. and P. H. Intorf.
A fire season severity index for California national forests. 7 p. Misc. Paper No. 14. October 16, 1953.

Describes a method of rating the relative severity of fire seasons based upon the effect of experienced weather on the number and size of fires. Tables are given showing the variation in severity by national-forest areas in the years 1945-52.

Neuns, A. G., and Albert Simpson
The use of 2,4-D and 2,4,5-T for brush control on California roads and trails. Revised May 1953.

Instructions for mountain roadside spraying brought up to date and a new section added to give instructions for spraying brush along trails.

Forest Economics

Baker, Harold L., and Adon Poli.
Area and ownership of forest land in Del Norte County, California. 23 p. Forest Survey Release No. 18. January 1953.

Forest Survey figures on distribution of land area by nonforest, noncommercial forest, and commercial forest land. Acreage of commercial forest land by timber type, age class, ownership, and size of holding.

Baker, Harold L., and Adon Poli
Area and ownership of forest land in Santa Cruz County, California. 22 p. Forest Survey Release No. 21. August 1953.

Forest Survey figures on distribution of land area by nonforest, noncommercial forest, and commercial forest land. Acreage of commercial forest land by timber type, age class, ownership, and size of holding.

May, Richard H.
Early history of the redwood lumber industry. Redwood Region Logging Conference Bulletin. 15th Annual Redwood Region Logging Conference. May 21-23, 1953. pp. 8-9.

An account of 19th century sawmill activity in northwestern California.

May, Richard H.
Timber production in the redwood region--1942 to 1951. Redwood Region Logging Conference Bulletin. 15th Annual Redwood Logging Conference. May 21-23, 1953. pp. 16-17.

Brief description of lumber production for redwood and the "white woods" of northwestern California.

May, Richard H.
A century of lumber production in California and Nevada. 33 p. Forest Survey Release No. 20. June 1953.

Compilation of available records of lumber production from 1849 through 1951; shows total production by years, species production from 1869-1951, county production 1920-1951. Text outlines early history and development of lumber industry in California and points out highlights of data.

Poli, Adon, and Harold L. Baker.
Ownership and use of forest land in the Coast Range Pine Subregion of California. 64 p. Technical Paper No. 2. June 1, 1953.

Results of cooperative study made by Bureau of Agricultural Economics and Forest Service. Detailed discussion of ownership in relation to use of forest land, types of owners, size of holdings, operating tenure, how acquired, how used, and effect of ownership on management.

Wieslander, A. E., and R. Earl Storie
Vegetational approach to soil surveys in wildland areas. Soil Science Proceedings 17(2): 143-147. April 1953.

Describes methods used in the concurrent mapping of vegetation and soil on more than 3 million acres of mountainous land in California. Examples of vegetation-soil relationships that aid soil mapping are pointed out. Charts illustrate some of the kinds of information that are obtained in the mapping and which can be put to use in managing the soil for timber and range purposes.

Forest Economics (Continued)

Forest Survey Staff
Forest statistics for the Redwood--Douglas-fir Subregion in California. 54 p. Forest Survey Release No. 19. January 1953.

Forest Survey findings for one of the major timber areas in California. Shows acreage of nonforest, noncommercial forest, and commercial forest lands. Distribution of commercial forest area by timber type, age class, and ownership. Timber volume by species and size class; growth of timber stand; and volume removed by cutting.

Range Research

Cornelius, Donald R., and Charles A. Graham
Chemical control of buttercup on mountain meadows. Jour. of Forestry 51(9): 631-634. September 1953.

Results of two tests, showing (1) that this range weed is susceptible to 2,4-D, (2) that the more desirable vegetation responds satisfactorily after spraying, and (3) the most efficient procedure for applying the spray material.

Fenner, R. L.
A safe, cheap, and effective forest fire grenade. Fire Control Notes 14(2): 22-24. April 1953.

Describes an inexpensive hand-thrown pyrotechnic device developed for fire control and for use where fire must be projected into inaccessible areas.

Graham, Charles A.
A practical way to evaluate spray distribution. Jour. of Range Mgt. 6(4): 255-259. July 1953.

Reports a method of checking spray patterns and coverage through use of paper previously dipped in a tannic acid solution. Droplets from aqueous emulsion sprays containing a small amount of ferric chloride record quickly on this paper and are easy to read in the field.

Talbot, M. W.
The Sixth International Grassland Congress. Jour. of Range Mgt. 6(1): 3-5. January 1953.

A condensed summary of purpose, scope, attendance and highlights of this Congress, sponsored jointly by the FAO of the United Nations, and the United States Government, held at Pennsylvania State College, August 17-23, 1952.

Forest and Range Influences Research

Hamilton, E. L., and L. A. Andrews
Control of evaporation from rain gages by oil. Am. Meteor. Soc. Bull. 34(5): 202-204. May 1953.

Reports studies showing that a layer of transformer oil 0.15 inch thick effectively protected water caught in rain-gages against evaporation.

Horton, J. S.
Supplement to checklist of the vertebrate fauna of San Dimas Experimental Forest. Misc. Paper No. 13, 4 pp. May 28, 1953

Adds 31 new species to those previously reported in California Forest and Range Experiment Station Misc. Paper No. 7.

Sinclair, J. D., and E. L. Hamilton
A guide to the San Dimas Experimental Forest. Misc. Paper No. 11. 19 pp. January 1, 1953.

Describes objectives and operation of the Experimental Forest, and includes an annotated bibliography of publications resulting from work of the experimental forest staff.

Gleason, C. H.
Indicators of erosion on watershed land in California. Amer. Geophys. Union Trans. 34(3): 419-426. June 1953.

The paper describes some indicators of erosion which can be observed on watershed land and suggests the use of these indicators in comparable disturbed and undisturbed areas to determine whether or not erosion has been accelerated by the disturbance.

General

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